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Members are hereby advised that the Subscription for 1885 falls due at the beginning of the year, and should be paid as soon afterwards as possible. The Council has decided that after January 1st, 1885, the 29th Bye-law will be strictly enforced, so that Members whose subscriptions are more than four months in arrear, will not continue to receive the Society's Journal.

Inquiries having been made as to the transactions of the Newcastle Chemical Society, the Committee of the Newcastle Section have to state that a very few complete sets are remaining, and will be sold to members at £2 10s. per set. A number of separate volumes can also be had by members wishing to complete their sets, at 10s. per volume (generally three years' issue). Application for these should be made to the Local Secretary of the Newcastle Section.

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MEETINGS, SESSION 1885—First Monday in each month (unless otherwise indicated).

March 2.—(1.) Mr. W. J. Kemp—"Some Experiments upon that part of Mr. F. B. Rawes's Patent for the 'Recovery of Sulphur,' etc., which depends upon the Action of Carbon Dioxide upon Soda Waste Suspended in a Liquid."

(2.) Mr. W. J. Williams on "The Treatment of Certain Phosphatic Minerals."

(3.) "The Stassfurt Salt Industry, and its bearing on other Industries," by C. Napier Hake and Charles Mook.

April 13.—(Monday *after* Easter)—Mr. W. J. Dibdin—"Further Notes on the 'Radial' Photometer, and the Proposed Standards of Light."

Notices of papers and communications for the meetings to be sent to the Local Secretary.

Meeting held February 2, 1885.

THE RUSSIAN PETROLEUM INDUSTRY.

BY BOVERTON REDWOOD, F.I.C., F.C.S.

SHORTLY after my return from a visit to Baku and the principal distributing centres of the petroleum trade in Russia, last autumn, it was suggested to me that some account of the Caucasian petroleum trade would be of interest to the members of the Society of Chemical Industry. Much has been already published on the subject; but it appeared to me, upon consideration, that the whole ground had not been covered, and that the members of this society might justifiably be addressed on the technical and commercial aspects of the question.

I propose to divide my remarks under three heads—viz., (I.) Production (as the obtaining of the crude petroleum is termed), (II.) Refining, and (III.) Distribution. Under the second head I shall deal with the properties and uses of the various products, and shall bring the third section to a conclusion with a very few words in reference to the routes to Baku, in the hope that some of those present to-night may be induced to make the trip. The majority of the statistics I shall give are from notes taken during my journey; but some are quoted from the valuable official reports of Mr. Peacock, H. M. Vice-Consul at Batoum, and from Mr. Charles Marvin's publications. I am indebted to Mr. Ludwig Nobel, as well as to Mr. Crusell, Mr. Ryden and many other officials of the Nobel Company, particularly Dr. Lagerwall, the courteous Secretary of the Company, for replies to many questions, and for affording me special opportunities of making myself acquainted with the industry. I have also to thank Mr. Burkhardt of Batoum, Mr. D. N. Sacker, agent in London for Mr. S. E. Palaschkowsky and the Batoum Naphtha Industry and Commerce Company, and Mr. E. G. von Glehn, representative of the Ragosine Company, for much valuable information.

I.—Production.

Anyone whose experience of oil-producing territory has been gained in the United States, cannot fail to be impressed, on first visiting the neighbourhood of Baku, with the very limited extent of the area within which, practically the whole of the crude oil is being collected. The oil-field from which the Baku refiners are supplied, is not in fact more than 3½ miles square; and on this small tract of land there are flowing wells or fountains which apparently could supply the whole world with lamp oil and lubricating oil. It must not, however, be assumed that the oil-bearing lands of Russia are of small area. On the contrary, it has been estimated that petroleum deposits underlie no less than 14,000 square miles, and admitting that this estimate is not based upon very reliable data, there is, I believe, no reason to doubt that something like 1000 or 1200 square miles of the Apsheron peninsula may be fairly regarded as more or less productive oil territory. No systematised attempts have yet been made to explore this large field, and strictly define its limits, for the reason that more than sufficient oil is obtained within the narrow limits I have referred to. The locality of the existing wells is termed the Balakhani or Balakhani-Saboontchi district, and it is distant about eight miles from the town of Baku, at an elevation of something less than 200 feet above sea level. A few miles away, at Surakhani, is another group of wells on the site of the prehistoric Sacred Fires; but these wells are of minor importance. Petroleum has also been obtained in quantity at Kouban, about 60 miles inland from Novorossisk, on the shores of the Black Sea; and evidence of the extension of the oil-field in a north-westerly direction has been furnished by the result of trial borings in the Crimea. In the neighbourhood of Tiflis, and in a large number of other places throughout the Apsheron peninsula, there are also petroleum pits and natural outflows of petroleum, some of which have been locally utilised. While, as I have said, the petroleum field appears to extend into the Crimea (though it is possible that there may be a succession of deposits rather than an actual belt), there is evidence of its continuous extension from Baku across the Caspian Sea to the Trans-Caspian territory. Near the Baku coast the surface of the sea is frequently covered with oil, which has floated to the surface; and in still weather the petroleum gas may be ignited. The island of Tcheleken, immediately opposite, and distant about 200 miles, contains apparently immense deposits of ozokerit. I hoped to have been able to visit this interesting place, but the Russian Government has, for political reasons, prohibited Englishmen from landing there; and in Russia the rigid passport-registration system makes every movement of the traveller known to the authorities. On the mainland, in the Trans-Caspian territory, there is stated to be abundance of petroleum; but except to supply fuel for the railway this source is not utilised.

The existence of the petroleum deposits of Baku has probably been known for 2500 years, for it is believed that the Persian fire-worshippers frequented Surakhani from the time of Zoroaster, who lived not later than 600 B.C. Gibbon states that in A.D. 624, the Emperor Heraclius wintered at the mouth of the river Kura, 70 miles south of Baku, and that his "soldiers extinguished the fire and destroyed the temples of the magi." Marco Polo, who wrote in the thirteenth century, is supposed to have referred to the petroleum of Baku when he stated that there was in this neighbourhood an abundant spring of oil not good for food, but good to burn, or to anoint camels that had the mange; and he added that people came from great distances to fetch it. In Jonas Hanway's time (the middle of the eighteenth century), Indians were worshipping at the Surakhani temple, as many as 50 pilgrims congregating there at one time. Hanway described the eternal fire as a flame in colour and gentleness not unlike a lamp that burns with spirit, only more pure, and sometimes rising to a height of eight feet, when the wind blows. I have on the table a photograph of this temple as I recently saw it. In the centre of a walled quadrangle stands a solidly built pillared and roofed rostrum of white stone, surmounted by a small trident. Around the boundary walls, with entrances from the quadrangle, are stone cells, which bear evidence of having been used as dwellings. Within these cells, and in the courtyard, there are many fissures in the ground, and upon applying a lighted match to some of these, I had no difficulty in igniting the gas, which burned with a flame of so little luminosity that in the bright daylight it was difficult to trace its outline. In some places channels of stone had been constructed to convey the gas. At the time of my visit there were neither officiating priests nor devotees, but a bell that had been used to summon the faithful, still remained suspended. Returning to the historical aspect of the subject, as to which I have only a very few more words to say, I may mention that Tcheleken island was referred to by Hanway, under the name of Naphtonia or Cherriken, as being peopled, when he visited it in 1743, by about 36 families, who had 24 large boats, owned several wells of naphtha, and carried on a brisk trade in selling the oil to Persians, Turcomans, etc. Colonel Yule states that the quantity of naphtha collected from the springs about Baku was, in 1819, estimated at 241,000 poods (more than one million gallons), the greater part of which went to Persia. Crude petroleum is still burned as a source of light in some parts of Russia, in earthenware lamps of primitive form, one of which I have on the table.

Very little is known concerning the geology of the Southern Russian oil-fields; and experience gained in petroleum-well boring in the United States, does not appear to be of much value in the Apsheron peninsula. Instead of the oil being found, as it is in America, in well-defined strata of sand-rock, it appears to exist in the Caucasus for the most part in separate cells or pockets. Professor Abich says the rocks can be assigned to the miocene formation, of which there are traces of two layers, above these being tertiary clays and sands; but the whole region has evidently been affected by volcanic action, and the strata have been broken up. Not far from Baku is an extinct mud volcano, from the sides of which petroleum exudes. The limestone found in the neighbourhood, much of which is so soft that it is squared for building with axes, is full of shells of molluscs; and this particular stone and petroleum seem to go together in the Caucasus. I remember, when visiting the Bradford oil-field in the United States, having a somewhat similar stone (a specimen of which is on the table) pointed out to me as a surface indication of petroleum. I do not propose to say much on the present occasion in reference to the various theories put forward as to the origin of petroleum. It is well known that while some are disposed to consider petroleum as a product of the destructive distillation of coal, many more look upon it as derived from the remains of marine animals. In addition, we have Professor Mendelejeff's ingenious theory that petroleum results from the action of water at a high temperature, and under great pressure, upon compounds of iron, manganese and carbon; and I would refer those who are interested in the question to this distinguished chemist's essay, entitled—"L'Origine du Petrole," published in the *Revue Scientifique*, of November 3, 1877.

The peninsula of Apsheron projects in an easterly direction from the mainland of Trans-Caucasia, and upon the southern shore of the bay thus formed lies the town of Baku. The northern side of this peninsula is tolerably fertile; but the neighbourhood of Baku presents the appearance of a desert of sand and rock, here and there stained black by the exudation of petroleum, and with occasional deposits of salt glittering in the sun. The only vegetation which thrives in this district is the prickly camel-thorn; and it may be imagined that a more dreary prospect is nowhere presented to the eye. The oriental-looking Tartar villages, with solid flat-roofed stone buildings, surmounted by the characteristic domed chimneys, form inconspicuous features in the landscape, hardly distinguishable at a distance from the surrounding desert; and at intervals along the so-called roads water wells of primitive form are met with. Strings of camels, bearing skins of petroleum to Daghestan villages; tall sheep-skin-hatted Tartars riding on small donkeys, and gaudily-painted Persian "arbas," or two-wheeled carts, to which I must again refer, add to the thoroughly Eastern character of the scene.

The contrast between this silent desert and the bustle and confusion of the oil wells is most marked. Within the area of the present producing territory derricks are crowded together, a network of pipes like so many gigantic serpents covers the oil-sodden ground, miniature mountains of sand thrown up by the spouting wells abound, and all the remaining space is occupied by lakes of crude oil, as well as storage tanks for its reception before it is pumped to the refineries.

I had seen wells in America that were considered remarkable in regard to the quantity of oil yielded, and had read accounts of the productiveness of the Russian wells, but I was, I must confess, wholly unprepared for the evidence of abundant supply afforded by the flowing wells, or fountains, as they are locally termed, which have been struck in the Balakhani district. These wells are invariably capped to prevent waste and damage to neighbouring wells, as I shall presently explain. One of the fountains was opened in my presence, and immediately with a roar a mighty column of oil more than a foot in diameter shot up to a height exceeding 100 feet, and continued to flow without diminution of violence as long as the valve remained open, forming a lake of oil to leeward of the well. The derrick over the well was 70 feet in height, and the oil column occasionally rose to at least double this height, while stones were distinctly seen to be projected to an even greater altitude. An American who was with me said he could compare the spectacle with nothing but the falls of Niagara, and there was certainly the same awe-inspiring effect in watching nature disgorging her treasure that one experiences when standing on the brink of the stupendous Falls. The photograph exhibited (see Fig. 1) represents a Caucasian oil fountain. The well I saw spouting (Nobel's No. 18) yields at the rate of 1,125,000 gallons per 24 hours whenever opened, and is by no means the most productive that has been struck, the Droojba well and Nobel's No. 9 well having for a time yielded about double that quantity per 24 hours. In the case of these two wells the pressure of the oil amounted to about 200lb. on the square inch, and the oil column was from 200 to 300 feet in height. In the instance of Nobel's No. 9 well no great proportion of the oil was lost before the well was capped, but the Droojba fountain was for no less than four months quite uncontrollable, and it is estimated that from 68,000,000 to 136,000,000 gallons were ejected during this period. This quantity of American crude oil was worth in the United States at the time from £700,000 to £1,400,000 sterling, but in consequence of the impossibility of storing it, the oil spouted by the Droojba well was practically unsaleable. Not only was the greater part of the oil lost, but great damage was done to surrounding well property, engine houses being buried by the sand thrown up. It may afford a means of realising the enormous productiveness of these wells, if I state that the well known as Armstrong No. 2 struck last autumn in Butler county, Pennsylvania, flowed for a time at the rate of 260,000 gallons per 24 hours, and is considered one of the most prolific wells ever known in the oil regions of the United States. The yield of this well, it will be noted, is only about one-eighth of that of the Droojba well or of Nobel's No. 9 well.

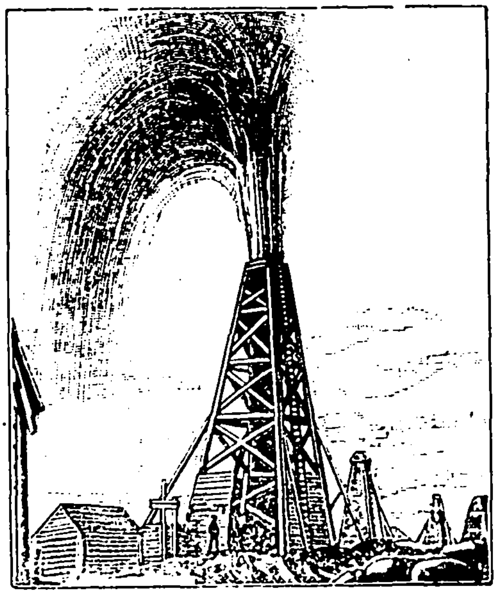


FIG. 1.

The first step in the operation of boring a well is the erection of a derrick. I have on the lecture table a model made for me in the United States which illustrates the method of construction, derricks of the same form being used in Russia. It will be seen that the structure consists of a timber framework, pyramidal in form and strengthened with diagonal braces. The sides of the derrick are frequently, I may say usually, enclosed with boarding to a considerable distance from the ground, to keep out wind and rain. The height of the structure is commonly about 70 feet, and it is about 20 feet square at the base. Immediately outside the derrick stands what is termed in America the Sampson-post, a massive pillar of wood some 18 inches square, which supports the "walking beam." The walking beam is connected to the crank of the band-wheel by what is called a pitman, and a rocking movement is thus imparted to it by the steam engine in the adjoining shed. There are two methods of boring in use in the Caucasus, termed respectively the rod system and the rope system, the latter being the more expeditious, and admitting of from 7 feet to 8 feet being bored per working day of 10 hours. In the rod system of boring the bit is screwed into an iron rod which may be as much as 40 feet in length, and a vertical movement is imparted to the apparatus by the walking beam already alluded to. As the hole increases in depth, additional lengths of iron rod are added, in the same way that the chimney sweeper manipulates his machine. At frequent intervals, however, it becomes necessary to remove the detritus from the bore, and when the well has been sunk to a considerable depth (say 200 to 300 feet), the time occupied in unscrewing each rod as the drill is drawn up, and reconnecting the rods after removing the detritus, is considerable. In the rope system, the set of drilling tools, consisting of temper screw, rope socket, auger-stem, the jars, and bit, are suspended by a stout cable of manilla. The aggregate length of this set of tools is over 50 feet, and the weight about a ton. The bits used in America are about 5½ inches in diameter, and are faced with about 40 pounds of steel, but in Baku the wells are of greater diameter and the bits correspondingly larger. As the boring of the well progresses it is cased with iron tubing, which is lowered in successive lengths. Tubing as much as 16½ inches in diameter is occasionally used in Russia, but the usual size with which the casing of the well is commenced is 15 inches diameter, the tubing being added in successive lengths of 7 feet. As the depth of the well increases and the larger tubing can no longer be driven down, smaller tubing is used, and the lower lengths are sometimes less than 8 inches in diameter. I have already stated that from time to time the detritus has to be removed. For this purpose the drilling tools are drawn up through the medium of the strong windlass (technically known as the bull-wheel) fixed to the side of the derrick, and actuated by the same steam engine that moves the walking beam, and then a few bucketsful of water having been poured into the well, the "sand pump" is lowered by means of a small windlass. This sand pump consists of a tube or cylinder of metal some 6 feet or more in length, having at the lower end a valve opening inwards. The detritus having entered the tube through the opening of the valve, the tube is withdrawn with its contents, and this operation is repeated as many times as are necessary. The cost of sinking a well is about £2000, more or less, according to circumstances, the irregular character of the strata rendering the operation more difficult and costly than it is in the United States. As soon as oil is struck, the great anxiety is to affix a cap to the upper end of the well tubing before the flow becomes unmanageable. A difficulty arises from the fact that the oil contains a great deal of sand, the violent flow of this sand-laden oil quickly cutting through a considerable thickness of iron. I saw in Balakhani several caps which had thus been rendered useless. The caps used are provided with a valve so that the flow may be controlled and regulated. In many cases it is found necessary to artificially strengthen the ground surrounding the well, in order to prevent the oil from making its way to the surface outside the tube when the flow is checked, and in the case of some wells the closing of the valve is attended with the risk of the cap being blown off by the immense pressure of the oil. It has more than once happened that on the oil being struck the outflow has taken place with such violence that the drilling tools, weighing as I have said a ton, have been projected from the bore. The employment of nitro-glycerine for increasing the production of a well, so common in the United States, has not, I believe, hitherto been resorted to in the Caucasus.

It is stated that there are over 400 wells in the neighbourhood of Baku (as compared with more than 20,000 in the oil-fields of the United States), but of these I was informed that only about 100 were at the time of my visit producing. Rather more than half the producing wells are owned by the firm of Nobel Brothers. Of the 100 wells only some 20 are flowing wells, the remainder requiring to be pumped; but from what I have stated as to the productiveness of the fountains, it will readily be believed that if the oil were allowed to flow, these 20 wells would for a time yield far more than sufficient raw material for the manufacture of the 1,800,000 gallons of petroleum burning oil which the world is now daily consuming.

The oil containing too much sand to admit of ordinary pumping, it is lifted to the surface by a contrivance similar to that which I have described as being employed for removing the detritus during the sinking of the well. The valved tube thus used holds about 45 gallons, and it is stated that from 18,000 to 22,000 gallons can thus be raised from each well per working day of 10 hours.

The average depth of the wells last year was 450 feet, having been in 1873, 154 feet; in 1880, 273 feet; and in 1882, 350 feet. It is estimated that the average level of the oil is lowered to the extent of 56 feet for every 500 million gallons extracted.

The No. 18 well (Nobel Brothers), which I saw spouting, has a depth of 721 feet. The boring was at first stopped at 500 feet, but the flow having ceased, the well was deepened. This well was struck three years ago. The depth of the famous Droojba well is 574 feet. I may add for comparison that 1500 feet or more is now by no means an uncommon depth for petroleum wells in the United States.

Soon after the annexation of Baku by Russia in 1801, the attention of the Russian Government was turned to the natural wealth of this district, and the production of petroleum was at first farmed out as a monopoly to Meerzoeff. This continued till 1872, and from then till 1877 there was an excise duty. During the period extending from 1821 to 1872 the yearly revenue from the petroleum monopoly was never far short of, and often exceeded, 100,000 roubles, and in the latter year it had reached the sum of 136,000 roubles. The output increased from 3565 tons in 1840 to 24,800 tons in 1872, but in two previous years—viz., 1869 and 1870—the output exceeded 27,000 tons. In 1872 there were only two drilled wells, in addition to 415 pit wells, and the price of the crude oil was 45 copecks per pood (about £3, 10s. per ton). The following tabular statement shows the growth of the industry from the time when the monopoly was abolished:—

PRODUCTION AND PRICE OF CRUDE PETROLEUM.

	Tons.	Price per Ton.	
		s.	d.
1873	64,000	7	9
1874	78,000	6	3
1875	91,000	15	6
1876	191,000	7	9
1877	212,000	12	6
1878	320,000	8	8
1879	370,000	6	3
1880	420,000	3	8
1881	490,000	2	6
1882	680,000	2	6
1883	800,000	2/6 to 0	3¼
1884	1,130,000		

The production of crude petroleum in the United States for 1884 has amounted to about 3 million tons, and the price has ranged from about 16/- to 32/- per ton.

The specific gravity of the crude oil is usually between ·870 and ·875; some wells have, however, yielded oil as heavy as ·885, and others oil as light as ·850. The specific gravity of the oil first obtained from Nobel's No. 18 well was ·860, but upon the well being deepened the specific gravity fell to ·854. The specific gravity of the crude oil now found in Pennsylvania ranges from about ·800 to about ·820. I have placed on the table samples of Russian and United States crude oil for comparison.

The crude oil is in the first instance conducted from the well through wooden channels to ponds or lakes, where it deposits the sand held in suspension, and it is then pumped into storage tanks prior to being piped to the refineries.

Formerly—that is, up to 1875—the transport of the oil to the refineries took place exclusively in the Persian carts or "arbas" I have already mentioned. These strange-looking vehicles are entirely constructed of wood, the body of the cart simply resting on the wooden axle, and the latter revolving with the wheels, which are often 8½ to 9 feet in diameter. The felloes of the wheels, being unprotected by tyres, are made of great depth to allow for the rapid wear to which they are subjected in traversing the rough roads, and the wheel becomes in use of smaller and smaller diameter until its dissolution, which generally seems to occur unexpectedly at the most inconvenient time. In these carts two casks were conveyed, one in the body of the vehicle, and the other slung beneath the axle. Thousands of these carts were in use prior to the era of pipe-lines: it is stated that as much as £100,000 per annum was paid for thus transporting the crude oil.

The first pipe-line from the wells to the refineries was laid by Messrs. Nobel Brothers, in the face of the most determined opposition on the part of the proprietors of the "arbas," who recognised that their business was threatened with extinction; and it is evidence of the lawlessness prevailing in the Caucasus that Messrs. Nobel were compelled to erect a line of watch-houses, wherein they stationed armed men to guard their pipe. Pipe-lines have some time since been accepted by the native carters as a necessary evil, but there is still much jealousy among the well-owners and refiners, and as the Tartars have no scruples about taking life, it is not safe for the visitor to traverse the district around Baku after dark without an armed escort, while even in daylight it is well to carry a revolver.

At the present time there are seven pipe-lines for the conveyance of crude oil, the two largest, which are of the respective diameters of 6in. and 5in., being the property of Messrs. Nobel Brothers. A certain amount of crude oil is also transported to the refineries by rail. More than 700 millions of gallons per annum could thus be delivered at the refineries, the Nobel Company's two pipes alone having a carrying capacity of 176 million gallons per year. Several telephone wires connect the wells with the refineries.

II.—Refining.

There are about 200 refineries in the Tchorni Gorod or Black Town, at Baku, but at the time of my visit not more than 50 or 60 were in operation. The works range in size from the primitive Persian refinery, with a couple of stills, to the gigantic establishment of Nobel Brothers, and at all these works petroleum residuum is the sole fuel used.

Messrs. Nobel's plant, for separating the burning oil or kerosine, as we may conveniently term it, consists of a large number of stills, each of the capacity of 4400 gallons, arranged in groups or series of not more than 25, and worked on the principle of continuous distillation, a stream of oil flowing through the entire series. Mr. Nobel informs me that this method of distillation is specially adapted for Russian petroleum, since from such oil only a comparatively small percentage of kerosene is obtained, and the residuum flowing from the stills is almost as fluid as the crude petroleum. The products of distillation are first separated into three fractions, termed respectively benzene, sp. gr. ·754; gasolene, sp. gr. ·787; and kerosene, sp. gr. ·820 to ·822. There is but little demand for the lighter products, and though a certain quantity is sold for detergent and manufacturing purposes, and a further quantity is employed by Messrs. Nobel as fuel, much has to be burned in waste to get rid of it. The kerosene distillate is pumped into lead-lined iron tanks, termed agitators, of the capacity of 57,000 gallons, where it is treated with about 1½ per cent. of sulphuric acid. The acid is forced up to the top of these tanks (which are above ground) by air pressure, and is distributed through perforated coils of leaden pipes, so that it falls through the oil in fine streams. The oil and acid are then subjected to agitation by introducing a blast of air at the base of the tank. After this treatment the acid is allowed to subside, and the oil is drawn off into a similar-sized iron tank without lead lining, standing at a lower level. In this tank, which is furnished with a similar method of agitating, the oil is treated with a solution of caustic soda, and is afterwards washed. Fresh water being very scarce at Baku, sea water is used for washing the oil as well as for the condensers. The sea water is brought into Messrs. Nobel's refinery from the Caspian by an aqueduct 5 feet in diameter, the intake being 7 feet below the sea surface, and 300 feet from the shore. The temperature of the water in summer is about 22° R. (82° F.). The kerosene is run from the washing agitators into settling tanks, where it deposits water, and thence is pumped into storage tanks (one of which at Messrs. Nobel's works holds 1½ million gallons), preparatory to being placed in the tank steamers for conveyance to the mouth of the Volga. The whole process of treatment of the distillate occupies from 15 to 16 hours. The sulphuric acid used by Messrs. Nobel is made by them in a separate factory, where 3100 gallons per 24 hours can be turned out. The sulphur was formerly imported from Sicily, but is now obtained from Tchirkat in Daghestan, near the port of Petrovsk on the Caspian. There is at Baku another factory, where sulphuric acid for the use of the other refiners is made. Although there are no laws or regulations in Russia prescribing a test for petroleum, Messrs. Nobel prefer to make a burning oil having a flashing point considerably above that which experience has shown to be sufficient to insure safety in the case of American kerosene, Nobel's oil having a flashing point of about 32° C., when tested by the German modification of Sir Frederick Abel's well-known apparatus. The oil has a specific gravity of about ·821, and is almost free from colour and odour. Of this oil the crude petroleum yields only about 27 per cent., but a much larger percentage of oil of lower flashing point or higher specific gravity could be obtained. Of oil absolutely free from colour, of sp. gr. ·823, and flashing point 50° C., Abel-Pensky test, the crude oil yields about 22 per cent. At another refinery which I visited (that of the Caspian Company), I was informed that the following grades of kerosene were made:—

Quality.	Sp. Gr.	Flashing Point.
1	·815	30° C.
2	·820	25° C.
3	·821/·822	22° C.

Of the first quality, some of which is exported from Batoum, the crude oil is stated to yield 20 per cent.;

of the second quality, sold in Russia, 33 per cent.; and of the third quality, sold locally for consumption in the Caucasian district, 38 per cent. The crude petroleum of the United States yields not less than 70 per cent. of kerosene.

The residue in the stills after the kerosene has been volatilised has a sp. gr. of about ·903, and is known by the Russian name of astatki, or by the Tartar name of masut. It is usually stored in large excavated tanks, lined with masonry. Messrs. Nobel have a cylindrical tank of this description holding 11 million gallons.

From the astatki, lubricating oil is obtained by distillation, but in Messrs. Nobel's works only about 10 per cent. of the astatki has hitherto been thus dealt with. Of the remainder, Messrs. Nobel use a small portion for the heating of their stills and boilers, and sell the greater part as fuel. The astatki yields about 30 per cent. of lubricating oil, and about 15 per cent. of what is known as solar oil (sp. gr. about ·860 and flashing point about 220° F.—closed-vessel test). The latter is a product intermediate in sp. gr. and flashing point between the kerosene and the lubricating oil, and is capable of being burned in suitable lamps, two of which I have on the table. It has by some refiners been termed pyro-naphtha, and Messrs. Ragosine have introduced it as a "safety burning oil," but so far it has been difficult of sale, and it is usually returned to the astatki and thus employed as fuel. I have on the table specimens of the various products to which I have referred. The crude petroleum of Baku differs from that of the United States in containing little or none of the solid hydrocarbons; some of the crude oil of this district appears, in fact, to be practically free from solid hydrocarbons, and I believe that ¼% is the largest quantity that any of it contains. On the other hand, the petroleum obtained from Messrs. Nobel's wells in the Island of Tcheleken, on the opposite side of the Caspian Sea, yields as much as six per cent. of solid hydrocarbons. It is well known that the paraffin obtained from American petroleum is a source of considerable profit, but while the Baku refiner is at a disadvantage in this respect, he is enabled to make without difficulty or expense a lubricating oil, which bears exposure to a temperature below zero of Fahrenheit's scale without becoming solidified.

There are in the Baku district other refineries besides those situated in the Black Town. One of these (Kokereff's) is at Surakhani, on the site of the Eternal Fires, the distillery immediately adjoining the temple I have already described. This refinery was built with the view of using the natural petroleum gas as fuel, and elaborate arrangements were made for collecting the gas and conducting it beneath the stills, but when I visited the distillery, astatki was being used as fuel. The abundance of natural gas in the neighbourhood of this refinery is shown by the fact that the gas is now, as it has been from time immemorial, largely used in lime burning. There is plenty of limestone rock, and the lime burners simply turn up the surface of the ground and apply a light to the gas.

Messrs. Nobel's refinery is not only the largest, best constructed and best conducted at Baku, but it compares, I think, on the whole favourably with any I have seen in the United States. Portions of it are fitted with Siemens's electric light, and some idea of its magnitude may be gathered from the fact that it contains no less than 45 miles of piping. It covers from 75 to 80 acres, but the total area of the works, if the ground occupied by the houses of the employés is included, is 120 acres. In this connection I may mention that Mr. Nobel has erected a number of handsome dwellings and a club house for the general manager of the works, the chemists and engineers, and has planted gardens which are irrigated with water brought from the Volga.

Mr. Peacock estimates that 8000 men are employed in the petroleum industry at Baku, the common labourers being nearly all Tartars, Persians and Armenians, while the coopers, carpenters and other skilled workmen are Russians, Finns and Swedes. The wages of the former class are as low as 10d. per day or about 25s. per month, while those of the latter class range from £3 to £6 per month.

The following table shows the amount of kerosene manufactured during the last 13 years by Messrs. Nobel Brothers and the other refiners :—

Years.	Nobel Brothers. Tons.	All other Refiners. Tons.	Total. Tons.
1872	..	16,100	16,100
1873	..	21,500	21,500
1874	..	23,000	23,000
1875	..	32,600	32,600
1876	100	57,000	57,100
1877	2,500	75,100	77,600
1878	4,550	93,000	97,550
1879	9,000	101,000	110,000
1880	21,000	126,000	150,000
1881	50,000	133,000	183,000
1882	72,000	130,000	202,000
1883	106,000	100,000	206,000
1884	157,100	191,300	318,100

The price at Tsaritsin was in 1878, 3s. per five gallons, and is now about 1s. 3d.

The total exports of kerosene from Russia for 1884 amounted to 37,900 tons, of which Nobels manufactured 15,000 tons.

I estimate the quantity of kerosene manufactured from American crude petroleum in 1884 at more than two million tons.

The following tabular statement shows the increase in consumption of kerosene in Russia per head of the population. The figures are Russian pounds :—

CONSUMPTION PER HEAD OF POPULATION.

1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882
1·09	1·76	1·93	2·30	2·91	3·07	3·96	4·18	4·13	6·11	6·11

The distilling plant of the Nobel Company would enable them to make per 24 hours, 220,000 gallons of kerosene, 80 tons of lubricating oil, and 1300 tons of liquid fuel, equal to a yearly production of at least 65,000,000 gallons, 27,000 tons, and 450,000 tons of the three products respectively. We have already seen that the quantity of kerosene made by this firm last year was 157,100 tons, equal to 42,700,000 gallons, and it is estimated that the sales of lubricating oil and residuum for the same period amount to 3000 tons and 250,000 tons respectively. If, therefore, Nobel's works were continuously in full operation throughout the year, there would remain a surplus available for export of more than 22 million gallons of kerosene, 24,000 tons of lubricating oil and 200,000 tons of liquid fuel.

The native petroleum industry is protected in Russia by an import duty on American kerosene of 55 copecks per pood, equal to about 3d. per gallon, and since 1873 the imports of American kerosene into Russia have diminished year by year. At the present time practically the whole of the kerosene burned in Russia is manufactured at Baku.

The quality of the kerosene made from Russian petroleum has been the subject of much discussion. When the oil was first introduced into Europe its high specific gravity led to the belief that it would not be found to burn well in ordinary mineral oil lamps. The fact was, however, overlooked that the crude oil yields so small a percentage of kerosene, that this product is necessarily very homogeneous, the various hydrocarbons composing it not differing very widely in specific gravity, boiling point and other characteristics. This feature is clearly shown by the following results, which I have obtained in fractionally distilling samples of Russian and American crude petroleum and kerosene obtained therefrom. A measured quantity of the liquid was distilled, and each distillate was $\frac{1}{10}$ by volume of the quantity taken for distillation :—

	Baku Crude Petroleum. (sp. gr. ·873)	United States Crude Petroleum. From Bradford District. (sp. gr. ·819)	United States Crude Petroleum. From Parker District. (sp. gr. ·804)
1st fraction—sp. gr.	·787	·725	·724
2nd " "	·812	·753	·742
3rd " "	·839	·776	·760
4th " "	·855	·801	·778
5th " "	·864	·822	·798
6th " "	·848	·836	·818
7th " "	·839	·837	·825
8th " "	·847	·839	·831
9th " "	·857	·813	·846

Remarks.—The distillation was throughout conducted without passing steam into the retort, and there was therefore, especially in the case of the Baku petroleum, some decomposition or "cracking" of the hydrocarbons, accompanied by the evolution of gaseous products, and deposition of carbon. This accounts for the low sp. gr. of the latter fractions of the Baku oil, and for the fact that there was not, in every case, sufficient of the 10th fraction to admit of the sp. gr. being taken. It was, however, only desired to indicate that the Baku petroleum yields comparatively little kerosene, and no arrangements were, therefore, adopted to secure the distillation of the lubricating oil undecomposed.

	Russian Kerosene. (sp. gr. ·822)	American Kerosene (sp. gr. ·803)
1st fraction—sp. gr.	·783	·748
2nd " "	·796	·759
3rd " "	·803	·778
4th " "	·814	·792
5th " "	·827	·802
6th " "	·831	·812
7th " "	·837	·822
8th " "	·838	·831
9th " "	·846	·838
10th " "	·864	·819

A reference to the tables will show (*a*) that the Russian crude petroleum contains a comparatively small proportion of the lighter hydrocarbons, and (*b*) that in the case of the Russian kerosene there is less difference between the sp. gr. of the lightest and heaviest fractions than in the case of the American kerosene.

I have made a large number of photometric tests of Russian kerosene burning in ordinary lamps in comparison with American kerosene, on various occasions during the past eighteen months, and in the following table I give some of the most recent results obtained, the Russian oil used in these experiments being of Nobel's manufacture, and the American oil ordinary kerosene of good quality. The test lamp was fitted with a Hinks's duplex burner, and two varieties of wick were used. What is termed the American wick was a wick of long-staple cotton loosely woven, the English wick being a comparatively hard, tightly woven wick such as is commonly employed in this country. I may take this opportunity, of stating that I have not found any exception to the rule that all mineral oils burn far more satisfactorily as well as more safely, when a wick of the character of the American wick referred to is used, and I am of opinion that too little attention has hitherto been paid to this important adjunct to the lamp.

	Russian Kerosene.		American Kerosene.	
	American Wick. Standard Candles.	English Wick. Standard Candles.	American Wick. Standard Candles.	English Wick. Standard Candles.
Maximum illuminating power	22·1	19·14	25·59	21·25
Minimum " " after 6 hours	20·5	17·4	22·21	19·16
Average " " during 6 hours	21·2	18·04	23·96	22·14
Percentage falling-off in illuminating power in 6 hours	7·2	9·0	13·0	20·9
Grains of oil consumed per hour	1137	981·6	1238	1213
Grains of oil consumed per candle-light per hour	53·6	51·4	51·6	51·7

It will be noted that the Russian oil did not with either wick give as much light as was afforded by the sample of American oil, but on the other hand there was considerably less diminution in the light as the level of the oil in the reservoir of the lamp fell, and I may state that the latter feature has characterised all the comparative tests I have made of the two kinds of oil. I have tested the Russian oil in various other forms of burner used in this country and on the Continent, and except in the case of a burner in which a metal cone was substituted for the usual glass chimney, I have found that it burns satisfactorily. I have therefore no hesitation in saying that it is adapted for use in ordinary mineral oil lamps.

Russian kerosene is, as I have stated, almost free from colour ; that which is manufactured by Messrs. Nobel being what is technically termed superfine white, according to the method of testing and standards of the Petroleum Association. Formerly the colour of refined petroleum was estimated by comparing it with that of a standard sample, the two oils being contained in bottles of the same size. Several years ago I had an apparatus constructed for colour testing, which is now on the table. It consists simply of an arrangement for holding two tall glass cylinders above a mirror in such a position that the images of the bottoms of the cylinders are presented side by side. The oil to be tested being placed in one cylinder, and a standard sample in the other, it is easy to make an accurate comparison of the reflected discs, which are, of course, tinted in proportion to the colour of the liquids. I found this mode of estimating colour preferable, in the case of a fluorescent liquid like petroleum, to that of looking down upon the surface of the oil while the tube or cylinder is held over a white surface. Soon after I commenced the regular use of this apparatus, Mr. Robert P. Wilson, a member of the Committee of the Petroleum Association, invented and patented (in 1870) the chromometer now largely used in the trade. This instrument consists of two tubes arranged side by side and furnished at the lower end with a small mirror, by means of which light may be reflected upwards through them, each tube having a screw cap with glass centre. Above the upper ends of the tubes is fixed a small box containing two pairs of prisms, and above this is an eye-piece.

Up to this time it had been the custom to use standard samples of kerosene for comparison; but these were liable to alter in colour, and it was by no means the least valuable feature of Mr. Wilson's instrument that glass standards were substituted for the liquid standards previously employed. In using the apparatus, one of the two tubes is completely filled with the oil to be tested, and beneath the other tube is placed one of the standards, consisting of a disc of stained glass about the size of a shilling. The mirror is then adjusted so as to project the light through the tubes, and upon looking into the eye-piece a circular field divided down the centre is seen, the halves being tinted to an extent corresponding with the colour of the oil and of the glass standard respectively. The dividing line is formed by the edges of the two pairs of prisms referred to, and the prisms are employed to bring the light from the two tubes into one eye-piece, in the manner shown in the diagram (see Fig. 2):—

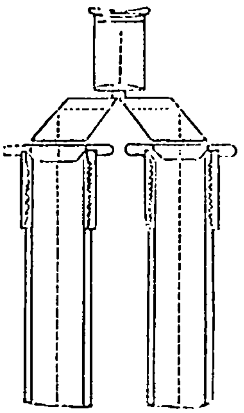


Fig. 2.

Wilson's chromometer was, after a sufficient trial, adopted in 1872 by the Petroleum Association, and is now in use in America and on the European continent, as well as in this country.

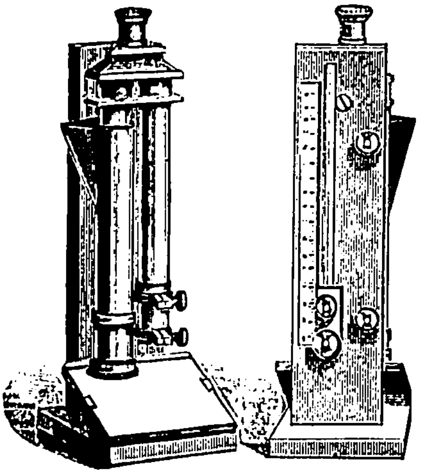


Fig. 3.

I have on the table a German modification by Stammer of this instrument (Fig. 3). In Stammer's apparatus, which in principle resembles the chromometer already described, the tube containing the oil under examination is open at the top, and is fitted with an inner empty tube, also open at the top and closed at the bottom by a disc of glass. The inner tube is in the first instance raised to the highest point, and a glass standard somewhat paler in colour than the whole column of oil having been selected, the inner tube is lowered, the oil being gradually displaced and the column of liquid shortened, until the two colours match, when the extent of shortening is read off on the scale. The precise colour of the oil can thus be recorded.

Lubricating oil made from Baku petroleum was, I believe, first introduced into England by Mr. Victor Ragosine, in 1877, and is now sold by the firm of Ragosine and Co., under the registered names of "Oleonaphtha" or "Ragosine Oil," in Germany, France, Austria, and Belgium, as well as in this country. This firm has two refineries on the Volga, north of Nijni Novgorod, capable of turning out a quarter of a million barrels a year. The crude oil and residuum are brought from Baku *via* the Caspian and Volga, and the refined products are conveyed to the consuming countries *via* the Volga and maritime canal to Cronstadt. The water route, though circuitous, is economical, and is likely to be adhered to until the raw material can be piped from Baku to the shores of the Black Sea. The imports of Ragosine lubricating oil into France and Belgium since 1877 amount to 187,000 barrels.

Russian lubricating oil, besides being, as a rule, practically free from solid hydrocarbons, and therefore bearing exposure to very low temperatures, without becoming solidified and thus clogging the bearings of machinery, has a remarkably high viscosity in relation to its specific gravity. This characteristic is very clearly exhibited in the following tabular statement of results which I have obtained in determining the viscosities of samples of Russian and American lubricating oils for the purpose of comparison :—

	Viscosity at 70° F.	Viscosity at 120° F.	Loss in Viscosity per cent.
Russian oil (sp. gr. ·913)........	1100	166	88
American oil (sp. gr. ·911)......	231	66	71
Russian oil (sp. gr. ·907)........	619	135	79
American oil (sp. gr. ·907)......	171	58	66
Russian oil (sp. gr. ·898)........	173	56	67
American oil (sp. gr. ·891)......	81	40	50
A sample of refined rape oil (for comparison)	321	112	65

It has been pointed out that although Russian lubricating oil has a very high viscosity, it rapidly loses its "body" upon being raised in temperature, and a reference to the viscosity figures for temperatures of 70° and 120° F. in the table will show that this is the case, the loss in viscosity between the two temperatures being in the case of a sample having a sp. gr. of ·907, 79 per cent. against 66 per cent. in the case of an American sample of the same sp. gr. Where it is desirable, however, to employ an oil of high viscosity at comparatively low temperatures, as in the lubrication of slow running heavy machinery, the Russian product is superior to the American. Moreover, it may be urged that it is because of its high viscosity that Russian lubricating oil is so much affected by a rise of temperature, for it will be noted that in the case of the American oils, as well as in that of the Russian oils, the diminution in viscosity is in proportion to the viscosity, the oils of greatest body being most affected. It is well known that mineral lubricating oils possess, as compared with fixed oils, the advantage of not being liable to decomposition under the influence of high pressure steam, or to oxidation. They are, therefore, well adapted for the lubrication of engine cylinders, and cotton waste used to absorb them is not liable to spontaneous combustion.

I have already stated that petroleum residuum or astatki is the only fuel employed in distilling petroleum at Baku. The most simple manner in which this fuel can be used is that which is adopted in the primitive Persian refineries, where the fluid is allowed to trickle upon the floor of the furnace beneath the still, and to burn there. The combustion is, however, under these circumstances, very far from complete, and volumes of black smoke are evolved. This smoke hangs in dense clouds over the Tchorni Gorod or Black Town of Baku, and is particularly offensive and destructive of wearing apparel and furniture, as it is so highly charged with oily particles of carbon that it may, in fact, be termed vaporous black paint. At the Nobel Company's refinery and some others efficient arrangements for the combustion of the astatki are adopted, and little or no smoke is evolved. Before I proceed to describe these arrangements, it will be convenient to consider briefly the development of the use of liquid fuel. As long ago as 1862 patents were taken out in the United States by Bidley, by Shaw, and by Linton, for the use of liquid fuel, and in 1864 experiments were made, at Woolwich, with an apparatus invented by Richardson. Aydon and Shpakovsky in 1865 independently devised arrangements for injecting the fuel into the furnace in the condition of spray, the former using at first superheated steam, and afterwards ordinary steam for the purpose, while the latter employed a blast of air. In the same year, Professor Rankine gave his attention to the subject, and in 1877, H. St. Claire Deville commenced a number of experiments at the request of the Emperor Napoleon III. Deville's apparatus was put to a practical test in Russia by Kamensky, and afterwards by Lentz in 1869, but proved a failure. In 1879 experiments were made at the Brooklyn Navy Yard, in the United States, with a mixture of crude petroleum and pitch, blown into the furnace by a jet of super-heated steam, and a very high temperature was obtained, iron being melted in 10 minutes and glass in 2 hours, as compared with 2 hours and 16 hours respectively when coal was employed as the fuel. In 1870, a steamer called the "Alexai" was fitted with an improved apparatus by Shpakovsky, and a successful result was obtained. Meanwhile, Lentz had also improved his apparatus, and either the Lentz oil burner, or some modification of it, is now employed in the better conducted refineries at Baku. The diagram (see Fig. 4) shows the construction of one of these modifications (Kaufman's) which has been adopted by the Russian Government for use in torpedo boats, the cylindrical flame afforded being well suited to the boilers of these boats. The astatki and steam meet at C D (see Fig. 4), where, by means of two screws, a fissure is opened through which they escape. The apparatus consists essentially of an arrangement for spraying, or, as it is termed in Russia, pulverising the oil by means of a jet of steam, a tongue of flame being in this way projected into the furnace. In thus using liquid fuel for the generation of steam, it is of course necessary in the first place to take a supply of steam from a small auxiliary boiler, or to raise steam by the use of wood or other fuel. The greatest objection to this kind of apparatus lies in the fact that the intensely hot pointed flame is liable to have a prejudicial effect upon the boiler, and it has been found necessary to employ screens of fire-clay, against which the flame is directed. Minor objections to the system are that it is wasteful (for, besides the loss of steam, the heat obtained from the astatki is from 10 to 20 per cent. less than it is capable of yielding), and that it is noisy, the roar of the blast being, in some cases, very objectionable. Nevertheless, the apparatus is very largely used, more than a hundred steamers on the Caspian and Volga, including those employed by the Nobel Company for the conveyance of kerosene, being fitted with it. Nobel's steamers, I may mention, consume 29 tons of astatki on the voyage from Baku to the mouth of the Volga and back. It is a novel experience to look into the stoke hole of a Caspian oil-burning steamer. Instead of grimy toiling firemen and coal trimmers, there is a single attendant whose sole duties consist in regulating the cocks supplying the astatki and steam. Consulting the pressure gauge from time to time, this attendant is able so to regulate the heat that there is neither a scarcity nor a superabundance of steam.

Liquid fuel is also now largely used on the Russian railways, including the Trans-Caucasian and the Griazi-Tsaritsin lines. In regard to its employment on the latter railway, Mr. Urquhart stated last year in *Engineering* that the combustion was smokelessly perfect, and that a practical evaporation of 12 to 13½lb. per lb. of petroleum was possible. He added that 3 or 4 tons of astatki can be run into the tank on the tender in about 4 minutes, the supply of water being taken in at the same time.

While travelling by train from Baku to Batoum, I noticed that although no smoke was emitted by the locomotive, there was occasionally a disagreeable odour of imperfectly consumed petroleum, but I have no doubt, that when the arrangements for burning astatki in such boilers are perfected, this source of annoyance will be removed.

Experiments with a stationary boiler in Messrs. Nobel's works show that one pound of astatki sprayed as described, vaporises 12lb. of water while the same quantity of coal only vaporises from 7 to 8lb. in the same boiler.

In consequence of the objections attaching to the steam-spraying method of burning astatki, Mr. Nobel has made a large number of experiments with the object of devising an apparatus in which satisfactory combustion of the fuel might be attained without the use of steam, and has recently patented an arrangement which appears to answer the purpose admirably. The apparatus consists essentially of a series of shallow receptacles or troughs, so arranged one above another at the mouth of the furnace, that the burning astatki flows by successive stages from the highest to the lowest. I have on the table one of these troughs, and the diagrams (Figs. 5, 6, and 7) illustrate a more recent form, as well as the method of applying the apparatus to the heating of steam boilers.

With this apparatus no less than 14½lb. of water can be vaporised by the combustion of 1lb. of astatki, the heating effect of the liquid burned under the two conditions described, as compared with coal being, therefore, as follows :—

Practical evaporation per 1lb. of fuel in a steam boiler at Messrs. Nobel's works.

Coal	7 to 8 lbs.
Astatki steam sprayed	12 "
Astatki burned with Nobel's system of troughs	14½ "

The most remarkable results have, however, been obtained in the use of Nobel's trough burner for metallurgical purposes. In a furnace at Mr. Nobel's engineering works at St. Petersburg I saw wrought iron reduced to a state of fusion, and horse-shoes, spanners, toothed wheels and other articles of soft iron can thus be easily and cheaply produced by casting in moulds. I have on the table specimens of this kind of iron work, notably a spanner, which has been bent double under a hammer without showing any signs of fracture. These results have been obtained without any heating of the air supply ; and there can be no doubt that if the air required for the combustion of the fuel were previously brought in contact with heated surfaces, much higher temperatures might be commanded. The difficulty of finding sufficiently intractable materials for the furnaces has, however, hitherto stood in the way of making experiments in this direction. Liquid fuel is thus practically applied for the fusion of iron and brass in Baku ; and it is found that old scrap iron may, in this way, be converted into a valuable soft grey pig iron. The employment of astatki for metallurgical operations is largely extending, and the freedom of the fuel from phosphorus and sulphur gives it a great advantage. The cost of astatki at Baku is about 2s. 6d. per ton, and it can be delivered at Tsaritsin, on the Volga, at about 8s. per ton. It is now much used in Moscow, and in localities as far distant as Stockholm and Teheran, no less than 1,500 tons per annum being shipped to Persian ports. Among the advantages of liquid fuel for steamships may be mentioned economy of space in stowage, as well as of labour and time in placing the fuel on board and supplying it to the furnaces, and the smokeless character of the combustion; the last-named being an important point in the case of ships of war.

We have now to consider a feature of the Russian petroleum industry, which is of special interest to the chemist, and seems destined to be of great commercial importance. I refer to the employment of astatki as a source of benzene, anthracene and naphthalene. The process employed can scarcely be said to have passed beyond the experimental stage ; but the apparatus I saw was of considerable size ; and I am assured that the trials have been conducted on a scale sufficiently large to demonstrate conclusively the practicability of the mode of operating. The astatki is decomposed in a cupola regenerative furnace, which has been patented by Mr. Nobel, to whom I am indebted for the following interesting particulars of the results obtained. The first destructive distillation gives from 30 to 40 per cent. of tar, containing from 15 to 17 per cent. of 50% benzol. By a second destructive distillation of the heavy oils remaining in the tar after the separation of the benzol, 70 per cent. of tar is obtained, containing from 7 to 10 per cent. of 50% benzol, 16 per cent. of naphthalene, 2 to 3 per cent. of dry "green grease" (or 30% anthracene), and 24 per cent. of pitch. There is also obtained in the process 75 to 100 cubic feet per cubic foot of astatki of gas having an illuminating power five times greater than that of coal gas. The regenerative furnace is first heated to 1000° C., astatki being, of course, used as the heating agent, and when it has become cooled in the process of decomposing the astatki it is again similarly heated, the gas remaining in the furnace and the coke deposited on the hearth being utilised as fuel. The furnace is stated to remain in working order without cleaning for twelve months. The world's consumption of benzol is probably not less than 7000 to 8000 tons per annum. London gas-tar contains about 1 per cent. of 50% benzol and 1 per cent. of 30% anthracene.

III.—Distribution.

The most remarkable illustration of the forethought, energy and enterprise which have throughout characterised Mr. Ludwig Nobel's action in the petroleum trade is afforded by the admirable system of transportation and distribution, which he has elaborated. It is well known that refined petroleum is usually carried in casks, holding about 40 gallons, or in tins of four gallons enclosed in twos in wooden cases. The latter package is comparatively costly, and is only employed in the case of oil intended for use in hot climates ; and as Russia produces but little timber available for barrel making, the difficulty of transport appeared likely to seriously interfere with the development of the trade. Under these circumstances Mr. Nobel conceived the plan of conveying the oil in bulk from Baku in tank steamers, tank barges, and tank railway waggons, to large storage tanks, whence it could be distributed in comparatively small quantities, in barrels which could be returned to be refilled. This system has proved perfectly successful ; and it is not too much to say that without its adoption the petroleum trade in Russia could not have reached its present magnitude. Tank railway cars had been employed for the conveyance of crude petroleum in the United States, long before Messrs. Nobel Brothers commenced using them in Russia ; but I am not aware that this method of transporting refined oil had been adopted in America. The credit, however, of having carried to a successful issue the shipments of petroleum in tank steamers, undoubtedly belongs to Mr. Nobel, previous experiments in this direction having proved unsuccessful.

The tank steamers employed by Messrs. Nobel Brothers were constructed at Motala in Sweden, and were floated in halves through the excellent canal system which Russia possesses to the Volga, where the forward and aft portions were united. These vessels are about 250 feet in length by about 28 feet in breadth, and have a draught when loaded of from 10 to 12 feet. The whole of the bows and forward part of the steamer forms one large cistern, furnished with two longitudinal bulkheads, and several transverse bulkheads to prevent oscillation of the liquid when the vessel is rolling in a heavy sea. The engines and boilers are amidships, and aft of these are two cylindrical vertical tanks, of a diameter about equal to the beam of the vessel, rising somewhat above the level of the deck. The general appearance of the vessels is shown by the photograph on the table. The total capacity of the tanks is about 225,000 gallons (equivalent to 5,500 barrels of 40 gallons each). The steamers are driven by screw propellers, and the engines are of 120 horse power, nominal. The fuel used is astatki or petroleum residuum, and the speed attained is about 10 knots per hour. Of such steamers Messrs. Nobel Brothers have, on the Caspian, 12. There are also half-a-dozen smaller steamers owned by other firms.

While loading, the steamers lie alongside piers extending into the sea from the neighbourhood of the refineries, the oil being conveyed on board through 8in. pipes, and the cargo of oil can thus be placed in the vessel in 4½ hours.

From Baku to the mouth of the Volga is a voyage of a couple of days, the distance being about 460 miles ; but the Caspian is a stormy sea, as I found to my inconvenience, and in the short trips which the steamers make the system of tank transportation has been severely tested, and has been proved to be free from risk. It is true that the prevailing winds on the Caspian are either north or south, and, therefore, dead ahead or astern ; but if tank steamers can traverse this sea without accident, there is probably no reason why they should not safely cross the Atlantic, and I doubt not that in time American petroleum will be shipped in bulk.

The Volga at its wide mouth is extremely shallow, and the tank steamers can proceed no further than a locality termed Nine Feet Soundings, about 20 miles from land, and 80 miles below Astrakhan. Here the oil is transferred to tank barges, in which it is conveyed to Tsaritsin (a distance of 284 miles from Astrakhan) or other distributing centres on the Volga, the transport of the oil from the Baku refineries to Tsaritsin occupying six days. There are 38 tank barges on the Volga, of which 20 are owned by Messrs.

DIAGRAMS TO ILLUSTRATE PAPER ON RUSSIAN PETROLEUM INDUSTRY BY MR. BOVERTON REDWOOD.

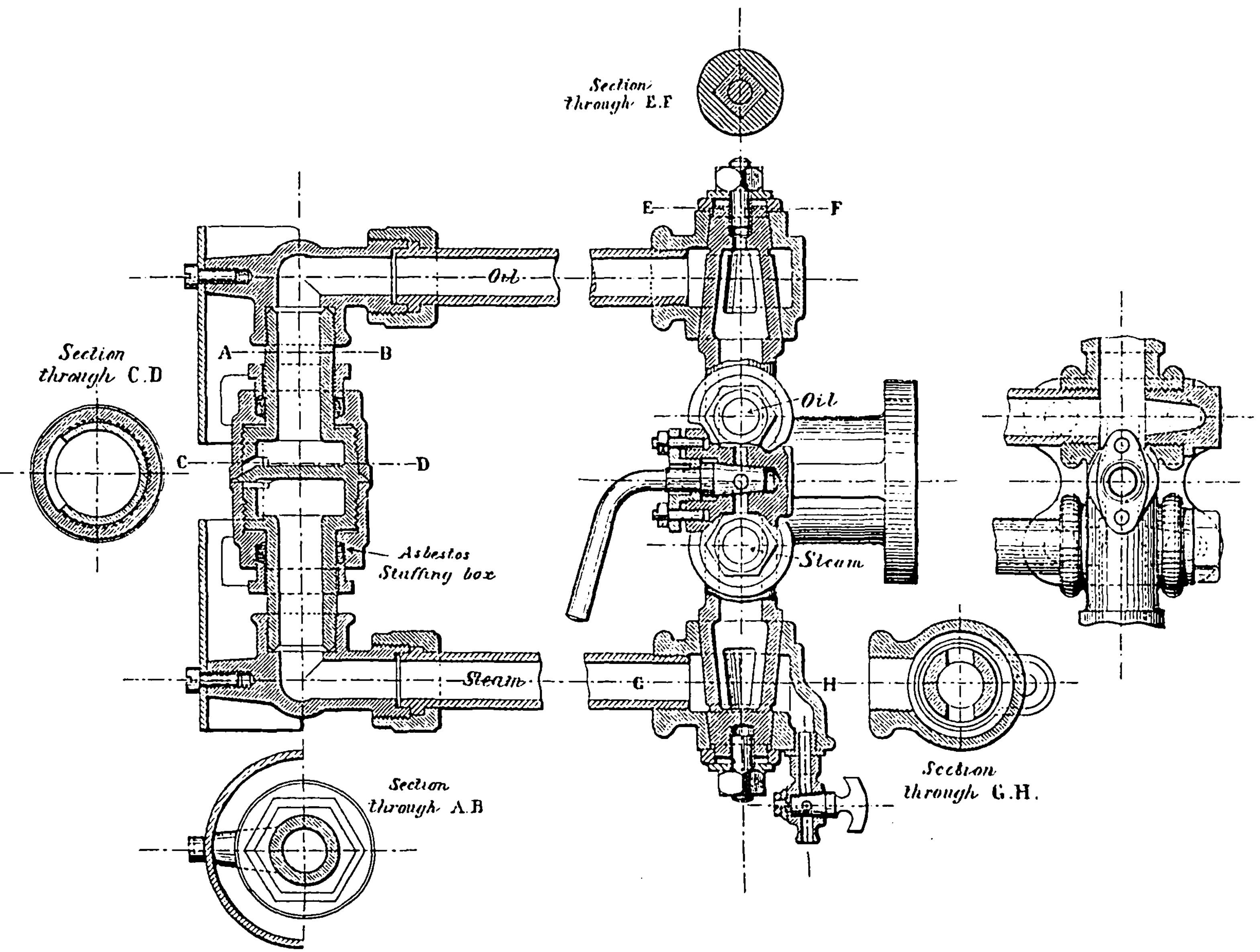


Fig. 4.—Kaufman Burner.

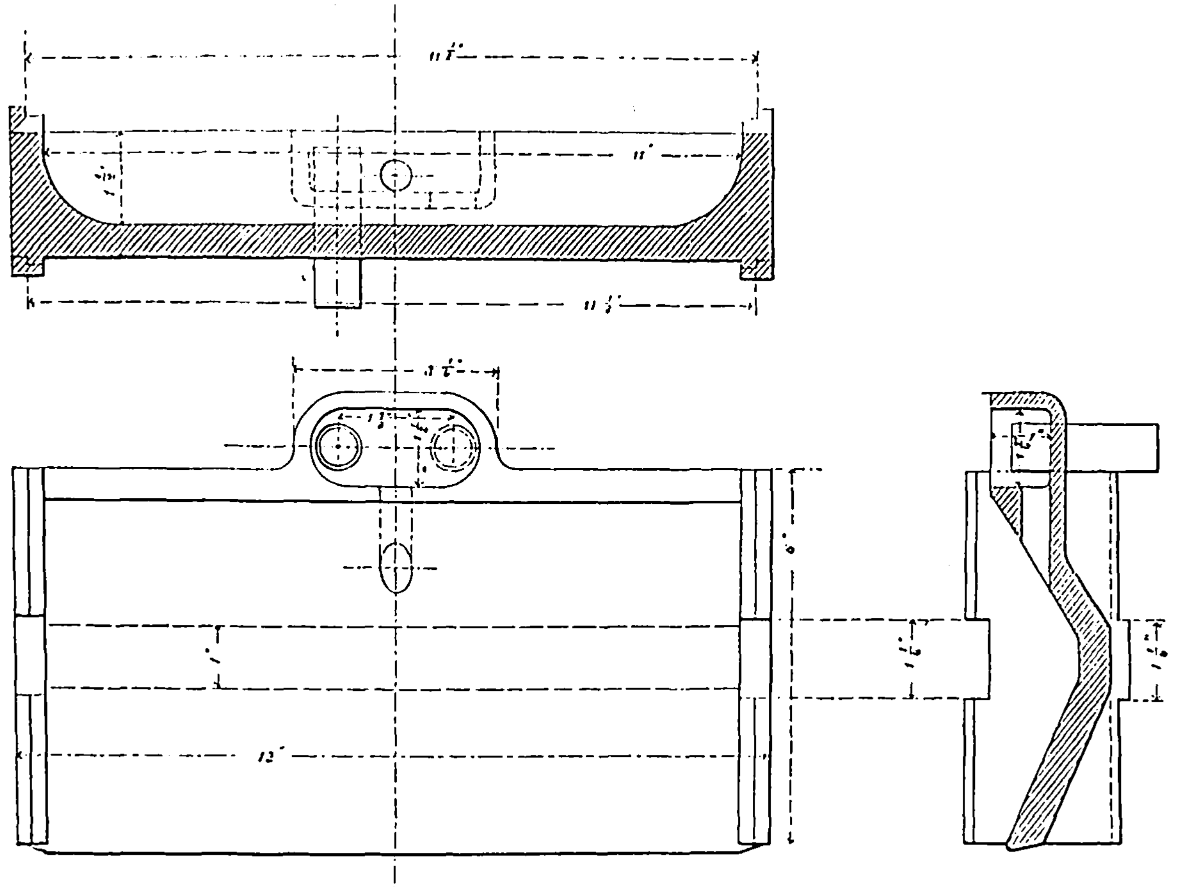
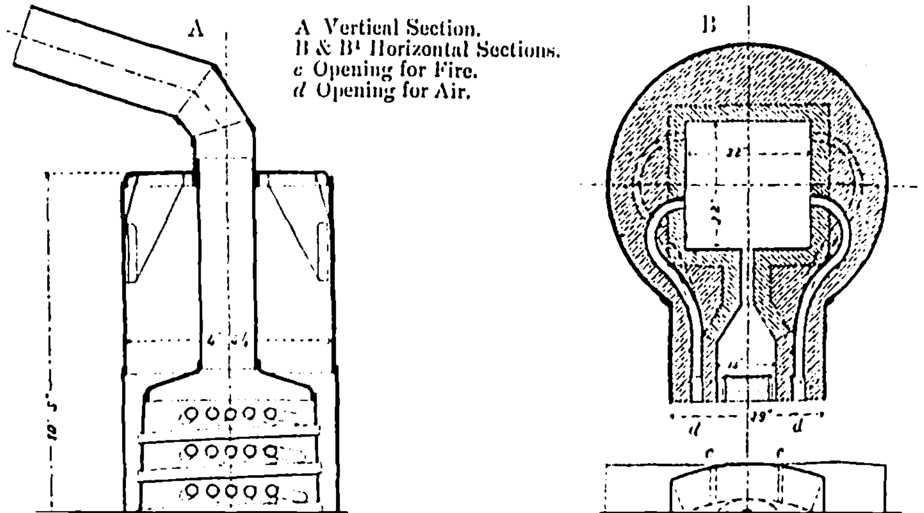
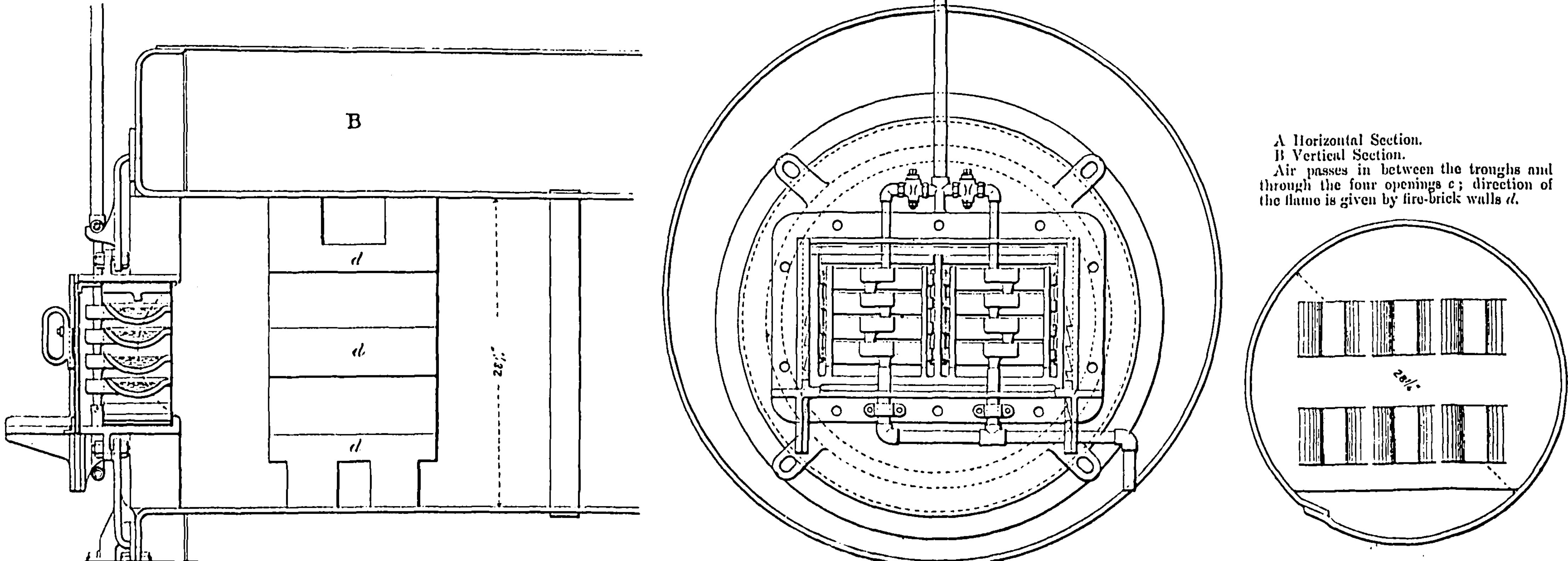


Fig. 5.—Nobel Burner (Trough).



A Vertical Section.
B & B¹ Horizontal Sections.
c Opening for Fire.
d Opening for Air.



A Horizontal Section.
B Vertical Section.
Air passes in between the troughs and through the four openings c; direction of the flame is given by fire-brick walls d.

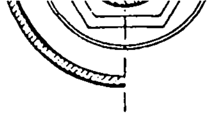
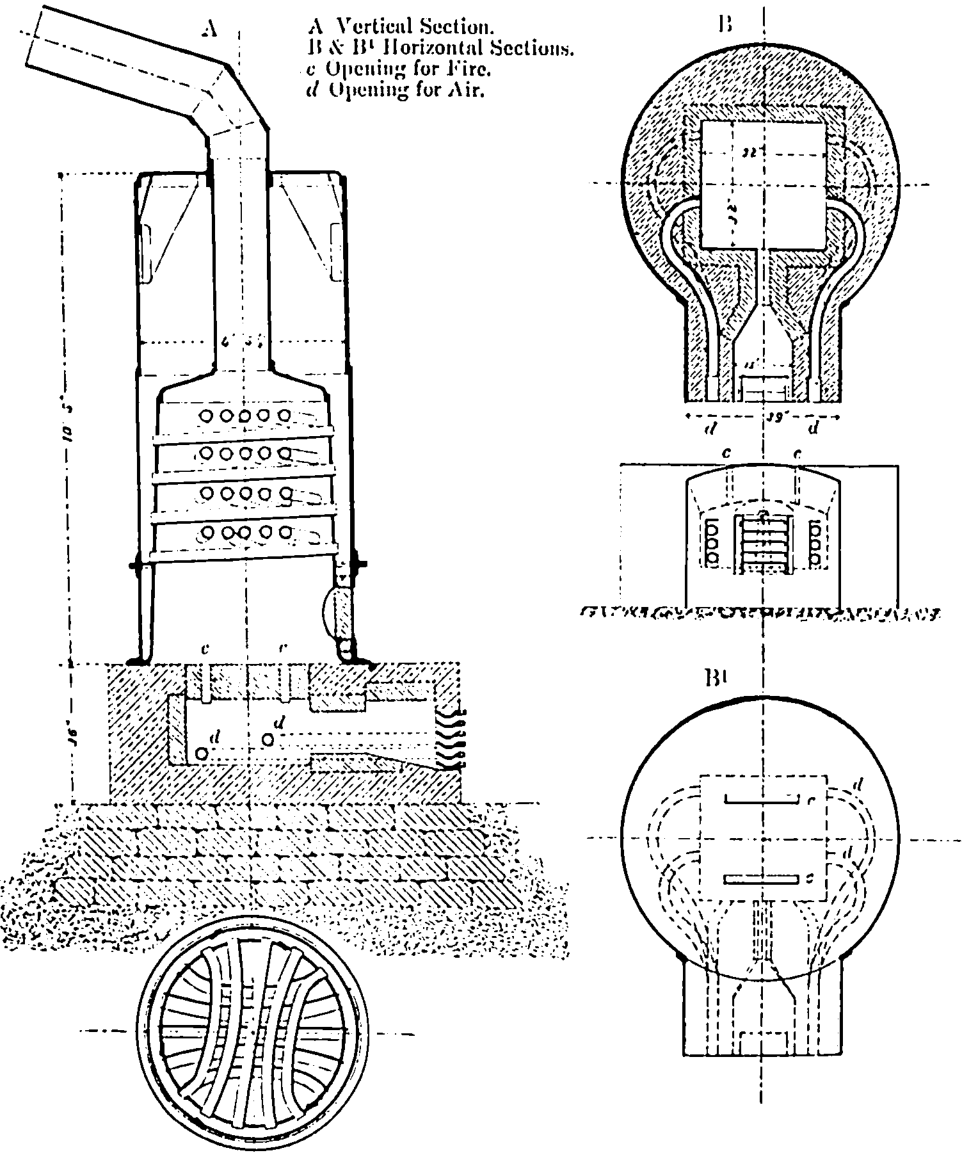
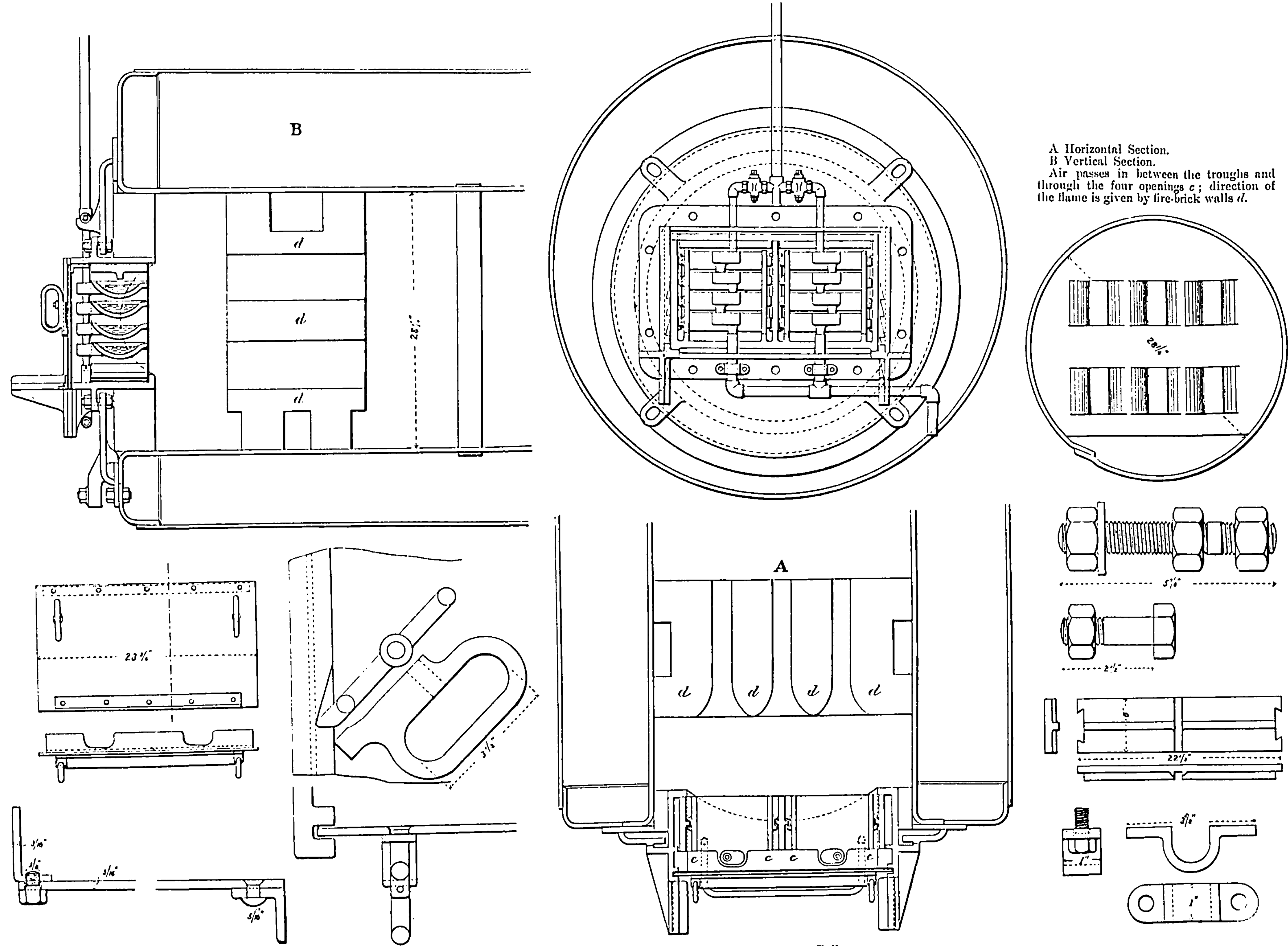


Fig. 4.—Kaufman Burner.



A Vertical Section.
B & B¹ Horizontal Sections.
c Opening for Fire.
d Opening for Air.

Fig. 7.—Nobel Trough Burner applied to Vertical Steam Boiler.



A Horizontal Section.
B Vertical Section.
Air passes in between the troughs and through the four openings *c*; direction of the flame is given by fire-brick walls *d*.

Fig. 6.—Nobel Trough Burner applied to Horizontal Steam Boiler.

Nobel Brothers. At Tsaritsin Messrs. Nobel Brothers have 15 storage tanks (holding collectively six million gallons), railway sidings, cooperage, etc., and the electric light is employed to facilitate work at night. There are also at this place some 30 tanks, of an aggregate capacity of nearly nine million gallons, belonging to the Caucasus and Mercury Company, and other firms; but many of these tanks are for the storage of residuum, while all except one of Messrs. Nobel's tanks are for burning oil.

From the storage tanks at Tsaritsin the oil is run into tank railway waggons, or barrelled, for conveyance by rail into the interior of Russia. Messrs. Nobel have on the Tsaritsin-Griazi railway 1,500 tank waggons, similar in form to those used in the United States, each waggon holding about 2,600 gallons of oil. A train is usually made up of 25 waggons, and thus Messrs. Nobel have 60 trains engaged in the conveyance of refined petroleum from Tsaritsin to their storage tanks throughout Russia. The railway company have also a considerable number of tank waggons of their own for the conveyance of the petroleum of other firms.

Messrs. Nobel have at Tsaritsin a barrel factory capable of turning out 500 barrels per day, much of the wood used being brought from Siberia by way of the river Kama.

The Nobel Company have established their principal storage and distributing centre at Domnino, near Orel, in Central Russia, where they have tanks capable of holding 18,000,000 gallons. They have also extensive tankage at Moscow, St. Petersburg, Warsaw, Saratow, and 23 other places, chiefly in Russia, the total storage thus provided being more than 36 millions of gallons. The necessity for providing for so large an accumulation arises from the fact, that the Volga navigation being closed from the latter part of November to April, the year's supply must be conveyed into the interior of Russia and placed in storage during eight months. An interesting feature of the working of this system of tank-waggon distribution may be witnessed at Messrs. Nobel's office in St. Petersburg. A map of Russia is marked with the various depôts and connecting railroads, and the clerk in charge being furnished from time to time throughout the day with telegrams informing him of the movements of the 60 petroleum trains, indicates the position of each train on the map by means of a small flag.

Until recently Messrs. Nobel were fully occupied in supplying the home demand for burning oil, but during the past year they have transported a considerable quantity across Russia into Germany, Austria and Belgium, and it is contemplated to ship oil from Libau in tank steamers.

The following estimate of the cost of Russian kerosene delivered in Stettin has been published by the Nobel Company:—

	Per Gal.
Cost of the kerosene delivered at Tsaritsin on the Volga, including general charges and a reasonable profit	1¾d.
Railway freight in Nobel's tank cars from Tsaritsin to Libau	1⅞d.
Charge for wear and tear of tank cars	⅛d.
Freight from Libau to Stettin	⅜d.
Proportionate cost of barrel at Stettin, with storage, discharging and leakage	1⅞d.
Total cost	6d.

Other firms have followed the example of Messrs. Nobel in the organising of bulk transport. The Caucasus and Mercury Company propose to provide tank steamers and barges capable of conveying 120,000 tons of oil from Baku to Tsaritsin on the Volga during the eight months that the navigation of the river is open, and have arranged with a Russian company for the conveyance of the oil from Tsaritsin by rail, and its distribution throughout Russia.

A glance at the geographical position of Baku will show that there are two principal outlets for the petroleum to western countries, viz., by the Volga, and across the Caucasus to the shores of the Black Sea. Hitherto I have dealt only with the former outlet, but as the latter promises to be at some future time of vast importance, I propose to describe it in detail. It is well-known that a line of railway, 560 miles in length, now connects Baku with the port of Batoum. A portion of this line was constructed many years ago, but the section connecting Baku and Tiflis has not very long been completed. It was anticipated that the railway from Baku to Batoum would have furnished a means of transport for large quantities of petroleum, but, unfortunately, from motives of economy, the older portion of the line was carried over what is known as the Suram Pass which has an elevation of 3,000 feet above sea level, and the gradient being in some places as much as 1 in 22, a train is limited to only six tank cars, though two Fairlie engines are used to draw it up the incline. The line also being a single one the traffic is congested, and I was informed that the transport of petroleum from Baku to Batoum, which costs about 1d. per gallon, has recently occupied from four to fourteen days. In order to overcome the difficulty, it is proposed to establish a storage depôt on the Baku side of the pass about 160 miles from Batoum, where the tank cars would discharge their contents, and from this point to lay a pipe line over the pass to Batoum so that the oil may be pumped up to the highest point and allowed to flow down to the shores of the Black Sea. It is the opinion of competent persons with whom I discussed the subject, that before Batoum can become a very important place of shipment for Baku petroleum, either the pipe line to which I have referred must be constructed, or the railway improved by laying a second line of rails and making a tunnel five miles in length through the Suram Pass.

The cost of the pipe line is estimated at three millions of roubles, while the tunnel would probably cost eight to ten millions of roubles. In any case extensive tank storage must be provided at Batoum, and it is thought that if, pending the construction of a pipe line or tunnel, there were adequate means of receiving and storing the oil at this port, the present railroad, if properly managed and provided with the necessary rolling stock, would be sufficient for the transport of from 40 to 50 millions of gallons per annum. Mr. Burkhardt of Batoum, informs me, in a letter received recently, that during the year 1884 there were shipped from that port about 14,500 tons of kerosene, 4500 tons of lubricating oil, and 4700 tons of astatki or residuum; a total of rather more than 6,400,000 gallons.

When I travelled over the line there were nominally 400 tank waggons for the conveyance of petroleum, but I was informed that less than 300 were available for use. I have, however, quite recently learned that the Russian Government has authorised the expenditure of 5,000,000 roubles in improving the means of transport of petroleum across the Caucasus, and that 750 new tank cars, 28 Fairlie locomotives, and extensive tank storage at Batoum and other points are at once to be provided. The sum of 3,000,000 roubles is now being spent upon harbour works at Batoum, and it is possible that before long petroleum may be shipped in tank steamers from this port.

The following table, for which I am indebted to Mr. Sacker, gives the distances in Italian miles of some of the principal petroleum markets of the world from Batoum and New York respectively :—

To.	From Batoum.	From New York.
Alexandria	1312	5030
Algiers	1978	3580
Amsterdam	3317	..
Antwerp	3185	3318
Bremen	3112	..
Havre	2990	..
Genoa	1910	4075
Gibraltar	1810	"
Hull	3212	..
Hamburg	3152	3576
Leghorn	1855	..
Liverpool	3110	3000
Lisbon	2121	2980
London	3190	3210
Malta	1417	..
Marseilles	2011	3913
Naples	1586	4200
Palermo	1507	4115
Smyrna	860	4882
Trieste	1768	4982
Constantinople	582	5260

At the present time practically the whole of the tank storage at Batoum is owned by Mr. Palaschkowsky, who has also a factory fitted with all the newest American machinery for turning out 6,000 tins and 3,000 wooden cases per day. I have already referred to this form of package as employed in the shipment of petroleum to hot climates. The cost of the complete case made in Batoum is 92 copecks (less than 2s.), viz., 28 copecks for the wood case and 32 copecks for each tin. American barrels are worth in Batoum about 6s. 6d. and barrels made in Baku cost about 8s.

It is contemplated to provide a third outlet for Baku petroleum by the construction of a railway line from Petrovsk, on the Caspian Sea, to Vladikavkaz. The line would be about 160 miles in length, and its estimated cost is rather more than £1,500,000 sterling. It has also been proposed to connect Novorossisk with Vladikavkaz and Baku with Petrovsk by rail.

The astatki is usually conveyed from Baku to Tsaritsin and other points on the Volga in sailing vessels and barges. When this fuel can be cheaply conveyed to Batoum or Poti it seems likely to compete with coal, of which about 300,000 tons are annually shipped (chiefly from England) to Black Sea Ports.

The two principal routes to Baku are (1) *viâ* the Black Sea and Transcaucasian Railway, and (2) *viâ* the Volga and the Caspian Sea. For those who can spare the necessary time, I would strongly recommend from personal experience the following circular tour:—London to St. Petersburg, *viâ* Hamburg, Copenhagen, Gothenburg, and Stockholm. St. Petersburg to Nijni Novgorod, *viâ* Moscow. From Nijni Novgorod down the Volga to Astrakhan. Astrakhan by steamer to Baku. Baku to Batoum by Transcaucasian Railway. Batoum to Constantinople by Austrian Lloyd's steamer, touching at Trebizonde and other places of interest, as well as great natural beauty on the coast of Asia Minor. Constantinople to London by the Orient express, or if time permits, home by way of Athens and the Adriatic. This journey is not far short of 8,000 miles in length, without the detour to the Piræus, and occupies about two months, including a reasonable time spent at various places of interest. It may be materially shortened by proceeding overland to St. Petersburg and by taking the rail from Moscow to Tsaritsin, thus cutting off a good deal of the tedious, but in some respects interesting, Volga journey of 1800 miles from Nijni Novgorod to Astrakhan. The Constantinople route home is also by no means the shortest from Batoum, and those who are pressed for time should take the steamer to Odessa. A route which is highly spoken of by those who have traversed it is from Rostoff-on-the-Don to Vladikavkaz by rail, and thence to Tiflis on the Transcaucasian Railway by road through some of the finest mountain scenery of the Caucasus. The shortest route from London to Baku is *viâ* Berlin, Odessa, and Batoum. By this route Baku is about 2,500 miles from London, and may be reached in 10 or 12 days without material discomfort or fatigue. As Baku is undeniably a hot place in summer, the visitor should not arrive there before the middle or latter part of September, and if the Volga route be selected Nijni Novgorod may thus be visited on the way to Baku before the closing of the great fair.

DISCUSSION.

Professor DEWAR, in thanking Mr. Redwood, called attention to the valuable results to be effected by utilising the volatile portion of the products obtained by distillation, for working gas engines.

Sir F. A. ABEL, in supporting the thanks, spoke of the application of the least volatile petroleum products as fuel for locomotives and steamers, and said he felt perfectly sure that, not only in the mercantile marine, but from the small torpedo vessels to the large men-of-war, where the saving of space was of such great importance, the introduction of liquid fuel would prove a new era in maritime power.

Replying to an inquiry as to the differences between Russian and American petroleum,

Dr. ARMSTRONG said that Russian petroleum was a material of very great interest to the chemist, as there could be little doubt that it was entirely different in composition from American petroleum. The American oil, it is well known, contained little besides hydrocarbons of the methane or C_nH_{2n+2} series. According to Markovnikoff and Oglobine (*Ann. Chim. Phy.* 1884, [6] 2, 372-484), whose investigations appeared to merit every confidence, the Russian oil contained a very considerable portion of benzenes (pseudocumene, several isomers of cymene, and also of its next homologue), and of other benzenoid hydrocarbons; it chiefly consists, however, of hydrocarbons of the C_nH_{2n} series, *isomeric* both with the olefines or true homologues of ethylene, and with the hexhydrides of the benzenes. These latter hydrocarbons exhibit the closest resemblance to the paraffins; but are of higher density than their isologues. They are attacked by chlorine, yielding chlorinated derivatives; but on oxidation are completely destroyed without furnishing characteristic products. The following is a list of the hydrocarbons of this group, which have been separated from the Russian oil :—

	B. P.	Density at 0° C.		Density at 0° of isologous normal Paraffin.
C_8H_{16}	119	·7714grm.	per cent.	·7188grm.
C_9H_{18}	136	·7808	"	·733 "
$C_{10}H_{20}$	161	·795	"	·7456 "
$C_{11}H_{22}$	180	·8119	"	·7557 "
$C_{12}H_{24}$	196	·8025	" (at 17°)	·7655 "
$C_{14}H_{28}$	240	·8190	"	—
$C_{15}H_{30}$	247	·8291	"	—

Liverpool Section.

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Vice-Chairman : J. Campbell Brown.

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E. W. Parnell.
C. Symes.
G. I. J. Wells.
F. Hurter.
H. Brunner.
A. Norman Tate.
J. Affleck.

Local Sec. : E. G. Ballard, Queen's Park, St. Helens.

Notices of papers and communications for the meetings to be sent to the Local Secretary.

The next Meeting of this Section will be held on Wednesday evening, March 4th, 1885, when Mr. E. K. Muspratt will read a paper on "The Rivers Pollution Bill."

University College, Ashton Street, Liverpool,
Wednesday, November 5, 1884.

MR. E. K. MUSPRATT IN THE CHAIR.

ON INSTRUCTION AND EXAMINATIONS IN CHEMICAL TECHNOLOGY.

BY A. NORMAN TATE.

I thought it might be well to bring before the members of this Society, for the purpose of opening a discussion, some items that I think should be considered with reference to the future progress of chemical industry. The members of this Society deal with processes based upon scientific facts and principles, and for the successful carrying out of these processes, there is required, not only a knowledge of these facts and principles, but a further knowledge and full appreciation of numerous technical details and practical skill in working these out. Now one of the chief objects of this Society is, or should be, the further development of chemical industries, and therefore, the question may be fairly asked, What is the Society now doing in furthering chemical industrial progress, and what else may be done to supplement present work? In one direction something is being done, and that is in the publication of the Journal, which month by month gives important information respecting chemical processes, and the opinions of those engaged in different departments of chemical industry, and thus form a medium of communication between the members that is extremely valuable. I would suggest that we should do something in the way of instructing workmen and others in the several facts and principles on which their work is founded, and training them in practical technical details.

There is very little done in this country, so far as I can see, in actual practical instruction in technology. There are certainly lectures on technology, and certain courses of instruction given in some of the colleges and schools throughout the country, but these courses are too frequently little more than mere lecture instruction, and not to my mind sufficiently practical; therefore, I think this Society may take some steps to encourage more practical instruction bearing upon technical details. Certainly there is much that is extremely valuable in the technological instruction given in Owens College, Manchester; University College, London; The Technical Chair of Chemistry in Anderson's University, Glasgow; and the Finsbury Technical College of the City and Guilds of London Institute, and other places; and the scheme of instruction fostered by this last-named Institution is probably one of the most complete schemes ever put forward, for, although not actually teaching all branches of technology, the Institute's scheme of examination indicates a fine field of technological work for students. But this scheme, admirable as it is, is, as I think, far from perfect, and unless great care is taken may lead up to, and in many cases end in, the answering by written answers certain printed questions, and many of the questions put are such as can well be answered by a clever crammer, destitute of any really technical skill. I have gone carefully through the questions in several subjects, and consider many of them quite unfitted to test technical knowledge. Many of them are such as may be put to elementary students in science subjects bearing upon the technological subject to which they refer, but they are not calculated to test a knowledge of technical details. Then, again, some of our best workmen cannot possibly succeed in such examination. A man may be able to work in a most admirable way and know everything necessary for successful work, but not be able to put his ideas into shape so as to properly describe the process on paper, and until we have a better educated race of workmen (and of course we may hope for that now that elementary education is given to all), such paper examinations are useless to a very large number of our most experienced workmen, who, if they attempted the examinations, would be most certainly plucked.

I therefore think this scheme of the City and Guilds of London Institute faulty and incomplete. But I certainly look upon what I consider its faults, as such only as are incidental to new enterprises, and probably useful additions will be made when further experience is gained. I cannot, myself, consider any system of examination in technology complete unless it includes some test of practical work involving actual supervision, for the very essence of instruction in technology seems to me to aim to give power to do work—that is, not only to understand all that is stated in a lesson, but power to work out in practical shape, with attention to all necessary details, that which is described or shown by the teacher.

I cannot help thinking that something may be done to promote sound instruction and examination in chemical technology by the Council of this Society, and I would suggest that it is advisable there should be appointed a permanent committee of the Society, and that the work of this committee should be to first ascertain what is being done in this and other countries in the way of affording facilities for instruction in chemical technology. The Report of the Royal Commission on Technical Instruction, lately issued, would form a most convenient and instructive source from which to give a preliminary report on the present position of chemical technology. Next, the committee might gather opinions and facts from amongst the members and others, as to the value of existing modes of instruction and examination, and make suggestions that would amend or add to them. And again, suggestions may be gleaned and passed round amongst members as to individual effort in promoting more careful study and working out of technological details—as, for instance, in the way of offering prizes to workmen and others who show themselves most fitted to receive them. The Society of Arts now offers prizes for inventions and work of different kinds, and could not this Society do something in this direction also? When the Royal Commission on Technical Instruction was taking evidence, nothing was done by this Society to afford information, but had such a committee as I suggest been in existence, probably much valuable aid might have been given by it.

In conclusion, I would say that I think we have to strive to give more complete technical instruction to workmen and others before they enter works, than is afforded by the lectures and courses of instruction given in our colleges and schools at the present time; and believing that a committee, such as I allude to, could aid much in promoting a better system of instruction, I suggest that this section passes a resolution asking the Council to consider the subject, and if they think fit appoint a committee.

Mr. Mond said in the early days of the Society this no doubt was one of its objects, but as they had gone on and become more numerous, it had gone into the background. There was a paragraph contained in the original bye-laws which had special reference to the promotion of technical education in chemical industry, but it was omitted in the new bye-laws. It had become a great deal more difficult to deal with any subject of the sort, through the many sections that had been formed. The consequence was that every step which the Society had to take had to go through the Sections, and opinions taken there; and it was really difficult now to get at the opinion of the Society as a whole, as the yearly meetings are no longer made use of for the purpose of ascertaining the opinion of the Society upon any special subject. His own opinion was that a very great deal was still to be done in the direction of getting technical education, he would rather say scientific education, in England. He would not say of improving it, but he said deliberately, a great deal had to be done in getting it. He certainly personally wished that their Society should do its share, if it could, in this matter. The notions with reference to technical education appeared to be peculiarly mixed up, and he was very much struck with the remarks of Mr. Tate, when he spoke of the young men who went to Owens College and other scientific institutions, and the figure which young working men would make if they had to pass an examination. There seems here to be a confusion between the education which had to be given to workmen and the education which had to be given to men who had to manage works. Surely these two questions should not be mixed up. They were as different as different could be. If it was desirable to give a certain grounding in natural science to working men—men who earn their living by daily wages—this ought to be done by primary schools, by teaching every child in the country a certain small amount of natural science and the general laws which govern the universe. To do more, he, for one, considered impossible. A man who had to earn his livelihood by daily wages could not afford to attend schools the object of which was to teach anything more than what could be taught at the elementary schools. As to teaching technology to men who were to manage works, he was of opinion that as little of it should be taught as possible. There he was at variance with gentlemen who now tried to teach technology. It was absolutely impossible in a school to teach that which was done in works. The only thing they could do was to make him understand the principles which governed what was done in works, by giving a sound scientific education Whatever else was wanted, he could only learn in practice. He thought the suggestion which Mr. Tate had thrown out was desirable to bring under the notice of the Council. His own opinion was that it was very desirable to make the Society as useful as possible.

The Chairman must say he agreed to a very great extent, if not with all, that Mr. Mond had stated. The fact was that there was a confusion in the minds of all Englishmen as to what technical instruction was, and what scientific instruction ought to be. They could not expect that they could teach in schools how to carry on chemical operations on a large scale. At the same time he thought that in teaching chemistry in their schools and in their colleges, it might be taught in very different ways by different teachers. Passing a pupil simply through quantitative analysis would not qualify him very well for taking part in chemical works. On the other hand, if the pupil had an opportunity of preparing substances in the laboratory on a somewhat larger scale, and carrying on chemical operations there to a greater extent than they did now, he would learn a great deal more of the behaviour of substances, and he would be more usefully instructed than by the courses hitherto given. People who employed chemists in works, knew that some of them differed very much from others, and that those who had been educated in some laboratories were much better fitted than others for their duties. All they could do was to teach science, they could not teach technology in schools. He knew that the Technical Institution in London, of the City Guilds, had endeavoured, and he believed were endeavouring, to teach technology. He thought it was a mistake—he used technology in the *narrow sense* of the word. He thought they would find that they could do very little in that direction, but he hoped they would be able to teach science in a different manner, and they ought to teach it in such a manner as to promote original research both in practical and scientific chemistry. In the course of time, he had no doubt, we should evolve in England some course of instruction which would be suitable for the condition of English manufacturers; but the Germans and some Continental nations who had much longer experience of this question of technical instruction, had, he thought, come to the view which had been enunciated by Mr. Mond, that you practically cannot teach technology in the narrow sense, and the art of carrying out chemical operations on a large scale they could not teach in any school whatever. That experience must be got in the works themselves. This excluded the possibility of carrying out Mr. Tate's desires. At the same time he thought it desirable that this question should be considered by the Society of Chemical Industry; but it was desirable first that they should discuss it in their sections, and if they came to the opinion that it was desirable to have a more general discussion, call the Society's attention to it. The proper way would be to pass a resolution in that section and send it on to the Council, and then it would be fully discussed. The object of the questions in the technological examinations should be to endeavour to find out whether the pupil understood the laws which lay at the basis of all operations in the chemical works. If he did that he would be properly qualified for taking part in chemical works, after he had a certain amount of experience in the works themselves.

Mr. Mond observed that lectures could never do more than give the pupils an idea of the apparatus used and the processes employed. They could not possibly teach how to perform the operations, either to design or use the apparatus. Lectures could only give a general idea of how the thing was generally done. The general idea was exceedingly useful, but it would never enable a man to carry the thing out. They would have to learn it practically in the works themselves. Even when teaching technology, the knowledge which was given was not only imperfect, but it was never up to date. The lecturers on technology could never know, and the text books never contained, the processes actually at work. Usually they were ten years behind the present time, and very often longer than that.

Professor Campbell Brown was exceedingly glad to have heard the remarks from Mr. Mond, and from the Chairman that evening, because he had long felt there was a great deal of misunderstanding in the popular mind as to what could or ought to be done in the way of technical instruction. The popular idea was that a young man ought to go into a technical college and be taught from the beginning to the end the whole process of making one thing whether soap, alkali, bleach or dye. It was perfectly clear that men did not learn these things without first learning a great many other things, and he was exceedingly glad to hear from Mr. Mond that technical details could only be learnt in the works, and what technical colleges had to do was to teach those who were to go into the chemical works, the laws of nature, and how to observe and report observations correctly. Mr. Tate had remarked upon the system of the City

Guilds Institute. No doubt the examination questions were sometimes very absurd, but they were not more absurd than examinations generally were. He believed it was a fact that examinations would never be able to determine who was the best practical man. They had signally failed to do so in the universities in this country, and probably everywhere else. He believed the system of examinations so enthusiastically carried on at South Kensington, was responsible for a great deal of the mistaken energy which had been devoted to this kind of cramming for science and art examinations. But when they looked away from the examinations, and saw what was being done in the way of teaching, they found a very different account. It was not by examinations, but by the teachers looking over the work from day to day and from week to week, and making a report of what was done, that they could pick out the best boy for practical work. In the ordinary examinations a boy might not be very well on the day he had to write his answers. He had known men who were perfectly capable of becoming senior wranglers that could not pass, because they had the toothache the night before. He was glad the members of the Society were prepared to state their opinion, and whatever the Society did it should be in order to get good preliminary training, to get pupils to observe the laws of nature, and then refer them to the works for technical details.

A discussion took place as to the form the resolution suggested by Mr. Tate should take, but it was ultimately agreed that the discussion should be renewed at a future meeting, when members would have sufficient opportunity of reading the report, or at least the recommendations of the Royal Commission on technical instruction.

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UNIVERSITY COLLEGE, ASHTON STREET, LIVERPOOL,

Wednesday Evening, February 4, 1885.

MR. E. K. MUSPRATT IN THE CHAIR.

THE CHAIRMAN stated that he had received a letter from the President of the Society (Dr. Perkin), who was endeavouring to get subscriptions to the Henry Watts Fund. There was enclosed a circular from the Birmingham Section, asking for subscriptions to assist Mr. Watts' widow and children, seeing how much industrial as well as scientific chemistry owed to Mr. Henry Watts. Mr. Muspratt thought they would all agree with him that it was desirable that they should do what they could towards this very worthy object. Mr. Watts did a great deal for chemistry, and his Dictionary of Chemistry was a most valuable work. Perhaps some gentleman would move that the Committee send out invitations to subscribe to the fund.

It was moved by Mr. CAREY, seconded by Mr. A. NORMAN TATE, that the Committee issue a circular, inviting subscriptions to the fund, on behalf of this Section.

The motion was carried.

The discussion on Mr. A. Norman Tate's paper, read November 5, was then reopened by Mr. Watson Smith, who contributed the following paper :—

ON A COURSE OF INSTRUCTION IN TECHNOLOGICAL CHEMISTRY, AND THE DIFFICULTIES AT PRESENT ENCOUNTERED AND TO BE OVERCOME IN THIS COUNTRY.

BY WATSON SMITH,

Lecturer in Chemical Technology in the Owens College, Manchester.

SINCE the subject of "Instruction and Examinations in Chemical Technology" has already awakened interest and discussion in this Section, Mr. A. Norman Tate having led the way with a communication bearing the above title, in re-opening the adjourned discussion, I may perhaps be excused for giving my views on a subject to me of the greatest interest. Taking the subject of general technical education in the first place, the division of the subject-matter made by the Royal Commissioners in their Report, is a fundamentally necessary one, for it is clear, as pointed out by Mr. Mond, that the kind of instruction needed by the different classes of persons engaged in technical pursuits, must from the very nature of things be different. This division is—

Firstly :—The instruction of the proprietors and superior managers engaged in industrial pursuits.

Secondly :—That of the foremen engaged therein.

Thirdly :—That of the workmen ;

and this division applies to the chemical industries as to every other branch of applied science. Commencing at the bottom and referring to the ordinary workman, a very elaborate degree of technical education would be out of the question, inasmuch as the people of the working class have neither time nor money to expend in obtaining it, but for boys belonging to this class, the board schools are already doing an enormous work. I need not, perhaps, remind Liverpool men of the great success which has attended the teaching of the principles of science under the auspices of the Liverpool School Board; but as the method of carrying out this scheme of science instruction may not be generally known, I will not apologise for reading extracts from the Report of the Royal Commissioners on the subject.

LIVERPOOL.

"*System of Science Teaching in Liverpool Board Schools.*—With a view to the provision in the curriculum of their schools, of some subject specially calculated to awaken and exercise the observing faculties of the children, the Liverpool School Board, acting on the advice of several eminent scientific gentlemen, in March, 1877, resolved to introduce the systematic teaching of elementary science into their schools. The branches of instruction were selected from the limited number of science subjects included in the fourth schedule of the New Code of that date, viz., mechanics (or, the principles of natural philosophy) for boys, and domestic economy for girls. The instruction given is necessarily based on the syllabus of each subject set out in the schedule, in order to qualify the scholars to earn grants under the Education Department; but in each case the subject, as arranged in the code, has been modified and extended so as to enable it the more readily to be taught by experimental demonstration to large classes of children.

"*Science Demonstrator in Elementary Schools in Liverpool.*—The method of teaching the subjects, which has been found by experience to be capable of producing very beneficial results to the scholars, is to combine ordinary lessons by the teachers of the school with a system of experimental demonstrations given by means of specially appointed demonstrators. The apparatus required for the demonstrations is kept at a central laboratory, and is transferred from school to school, as required, by means of a light hand-cart. In this way each demonstrator is able to give from 18 to 20 demonstrations per week. In order to simplify the arrangements for the demonstrations as much as possible, by providing for the same demonstration to be given in several schools in succession, the Education Department was, at the commencement of the scheme, requested to provide for the school-years of the different schools to end as nearly as possible at the same time; and this was carried out so far as to admit of the schools being arranged in two groups, the annual examinations of which fall in the autumn and spring respectively. In the case of domestic economy, the demonstrations are given only every alternate week, and the same is the case in the second stage of mechanics (taken by the Fifth Standard), but to the Fourth Standard, just commencing the subject of mechanics, one demonstration is given every week. In the intervals between the demonstrations, the teachers of the respective classes, who are supposed to be present at the demonstrations, are expected to go over with the children the subject of the demonstration; and in many instances their lessons are illustrated by simple experiments; and in order to enable the teachers (the larger number of whom have unfortunately had no special training for the subject) to perform their portion of the work the more satisfactorily, a simple text-book has been specially prepared, containing reading lessons on the subjects of the demonstrations, and exercises to be worked by the scholars. The demonstrations have been given in several of the other elementary schools of the town, not under the Board, on payment by the managers of the schools, of a proportion of the expenses.

"At the present time there is one chief demonstrator, who has also to organise the instruction, and two assistants.

"The cost of the apparatus used in the school demonstrations for the five years during which the scheme has been in operation amounts to about £120, many of the articles having been provided in duplicate in consequence of the large number of classes.

"*Science Tuition of Pupil Teachers in Liverpool.*—In addition to the instruction given to the scholars, special science classes in connection with the Science and Art Department, have been arranged for the pupil teachers, so as to gradually train them to take an intelligent part in the work in the schools. About 70 male pupil teachers attend the central classes in mathematics, acoustics, light and heat, and electricity and magnetism; and about 100 female pupil teachers are under instruction in animal physiology. A short course of lessons in mechanics is also given each year to the male pupil teachers.

"*Liverpool Council of Education.*—Mr. Christopher Bushell explained to us the action of the Liverpool Council of Education, a body of which he is the president. The object of the Council is to connect the Elementary Schools in the city with the Secondary Schools. For this purpose a system of prizes and exhibitions has been established, and independent examiners report on the quality of the papers which are set by them, and the Council acts on this report in their selection of the candidates. From the Secondary Schools the boys obtain an opportunity of passing to the higher colleges or to the Universities of Cambridge and Oxford.

"*Evening Science Instruction in Liverpool.*—A very important feature in the educational institutions in Liverpool, is the systematic series of evening science classes. There are two distinct organisations founded for this purpose, each of which carries on classes under the Department of Science and Art, without interfering with the other. They act as friendly rivals, and the result is that, probably, in no city in the kingdom are these classes more flourishing, or doing better work than in Liverpool. One of these organisations is termed the 'Liverpool School of Science,' the other 'The Liverpool Science and Art Classes.'"

MANCHESTER.

"*Elementary Instruction of the Manchester School Board.*—The Commissioners inspected many of the schools under the direction of the School Board of the city of Manchester. The average attendance in this city for the quarter ending September, 1883, was: Voluntary schools, 25,736; and board schools, 19,992; or 1 in every 7·5 of the population, and the cost to the ratepayers during the last five years has been 2d. in the £. Statistics of the School Board and particulars of the visits paid to the schools will be found in the Appendix, Vol. IV.

"*Manchester Higher Elementary Schools.—Science Teaching and Evening Classes, under School Board.—Manual Work.*—The points of special interest as regards technical instruction are: (1) The foundation by the Board of so-called graded schools, or higher elementary schools, into which the more advanced or most talented children from the primary school can be drafted, and where the higher subjects, especially science and drawing, are taught more satisfactorily and more economically than can be done in a school containing children of all ages and of all stages of progress; (2) The establishment by the Board of a systematic series of science and art evening classes, as well as of evening schools, for providing instruction in reading, writing, and arithmetic, for those who have had no opportunity of learning when young; (3) The establishment of classes for instruction in the use of tools, in two of the Manchester Board Schools.

"*Central School.*—Of the higher elementary schools two may serve as examples. The first and most remarkable of these is the Central School in Peter Street, taken over by the Board in 1880, and now transferred to new and most complete premises in Deansgate. The results of the science teaching in this school are well worthy of notice. Out of a total of 320 boys, 276 have passed Standard VI., and are taught during the day mathematics, physiology, chemistry (both practical and theoretical), sound, light and heat, magnetism and electricity, physical geography, and mechanics. French, too, is taught throughout the school. A girl's higher elementary school forms one-half of the building.

"*Practical Chemistry.*—The total grant from the Science and Art Department earned by this school in 1882-3 was £398. Practical chemistry is extremely well taught; no less than 163 boys, of whom 28 are advanced pupils, were engaged in laboratory work in the winter 1883-4, as well as 20 girls, and the new school buildings in Deansgate contain a laboratory well fitted and arranged for 70 boys working at once, with a lecture-room attached seating 100. Every boy in the school learns drawing upon the South Kensington method.

"*Scholarships.*—To the boys' school is attached one for 200 girls, and 20 scholarships exist for necessitous boys and girls from the primary schools. These are of the greatest service, as they form the first step in the ladder by which a talented boy may climb from the board school to the University. Other scholarships take the boy from this higher elementary to the Manchester Grammar School, and others again from that to the University. Several boys have already accomplished this feat.

"*Ducie Avenue School, Manchester.*—The other higher elementary school visited is that in Ducie Avenue. This is a new school containing 900 children in four departments; it cost, with land, fittings, and chemical laboratory, about £11,000. The upper school fee is 9d. per week, the lower 6d. and 4d. Both boys and girls are taught science, and both—viz., 69 boys and 46 girls, work in the chemical laboratory, which is in a separate building, well lighted and ventilated, and having a special class-room attached; of the boys, 136 are in Standards VI. and VII., or above, and of the girls, 96. The grants earned by this school from the Science and Art Department were £112; and this, together with the school pence, more than cover its working expenses.

"These two schools may be taken as an example of what can be accomplished by the School Board in a large city, even with as low a rate as 2d. in the £; and although in appliances of certain kinds these schools are less completely furnished than many Continental schools, your Commissioners have seen none which surpassed them in general efficiency, or in the tuition of any special subject, except in that of drawing."

BIRMINGHAM.

"*Birmingham School Board, Science Instruction.*—On the occasion of their visit to Birmingham, the Commissioners met the members of the School Board, and inquired into the system of science and art teaching under the Board.

"*Board School Instruction in Elementary Science.*—Science is taught in accordance with the following syllabus, by a practical demonstrator and assistant (who visit each boys' and girls' department once every fortnight), and by the teacher of the school.

"*Method of Instruction.*—The science demonstrator for the Board (or an assistant demonstrator) gives one lesson fortnightly, of about 40 minutes' duration, to the boys in the fifth and higher standards in each school. These lessons are illustrated experimentally by specimens and apparatus, carried from school to school in a hand-cart.

"Between the visits of the science demonstrator at least one lesson is given to the same class by the teachers of the respective schools (as a rule by a teacher who was present at the demonstrator's lesson, and took full notes of it), and a written examination on the subject-matter of the lesson is also held. The answers are corrected by the class teacher, and submitted to the demonstrator at his next visit to the school. A general examination in elementary science is held yearly.

"*Syllabus of Fortnightly Demonstrations for Boys.*—Specification of a force; nature and action of machines; principle of work. The mechanical powers; conditions of equilibrium; the mechanical advantage; friction. The lever; parts of a lever; three orders of levers. Practical applications of the lever; double levers. Weighing machines; the balance; the steel-yard. The wheel and axle; practical applications of this machine. The toothed wheel; clocks and watches. The pulley; fixed and movable pulleys; the three systems of pulleys. The inclined plane; its principle and applications. The wedge. The screw. Compound machines. Pressure of liquids; surface of liquids; liquids under the action of gravity. The hydrostatic press. The parallelogram of forces. The parallelogram of velocities.

"*Syllabus of Fortnightly Demonstrations for Girls.*—Structure of the human body; names and positions of the various organs; structure of the skin; the teeth. *Circulation and respiration; impure air and ventilation.* The organs of digestion; the brain and nervous system. Nature of food; necessity for food; quantity required; classification of food. Preparation of food; meat: its *composition and culinary treatment. Fish, eggs,* milk, butter, cheese: Principles regulating their use and preparation as food. Flour, pulse, peas, beans: their composition and preparation for the table. Starch, sugar, fruits, vegetables: *their use as food.* Condiments and beverages. Apparatus for cooking: how used. How to maintain the body in health: I. Fresh air and pure water are needful. II. A suitable dwelling, sufficient food, and exercise (work) are also required. The sick room: duties of a nurse. Contagious diseases: their origin and treatment. How to prevent them spreading. Diseases of children: how to help the doctor. Accidents: what to do in cases of cuts, burns, &c.

"*Science Evening Classes under School Board, Birmingham.*—Classes for the evening instruction of pupil teachers are held at two centres, under the regulations of the Science and Art Department. Male pupil teachers take chemistry and magnetism and electricity; and females, physical geography and magnetism and electricity.

"The Commissioners visited the Icknield Street Board School, which has been provided with an excellent laboratory, in accordance with the requirements of the Science Directory. Here some of the senior boys and the pupil teachers have practical laboratory instruction in chemistry.

"Instruction in handicrafts is not as yet given in any of the Birmingham Board Schools, but this matter is under the consideration of the Board."

Thus we see that for those working men having a real love and aptitude for the pursuit of science the evening classes of the Science and Art Department offer ample opportunities, and the abler boys from the primary schools can pass by exhibitions to the higher institutions in the town. *This connection between the higher board schools and the colleges, and even universities, is one which ought to be much extended,* and on this point I desire to lay the greatest stress. In this country, it can at present only be established by the voluntary movement of generous hearts and open hands. On the Continent, in Germany, it follows as an establishment of law, effected by so-called paternal governments, albeit both wise and far-sighted.

The Foremen are usually chosen in our industries, as indeed the name indicates, from the best workmen, and so the education would be much the same as that for the men, and here other characteristics also would come in, helping to raise the men to this next step higher, that of foremen, as conscientiousness, presence, and power of command, physical strength, etc., which certainly do not form subjects for either examination practically or on paper. But still, those of these men who are the best, and have taken fullest advantage of their opportunities, are the ones that must in the end best succeed. That this feeling has now become a common one, is borne witness to by the fact of such large numbers of candidates for instruction in the great centres of industry. Amongst the other means now accessible to the poorest of our countrymen are the evening classes under the Science and Art Department, in which purely scientific tuition is obtained, and most wisely and excellently engrafted on to this is the scheme of the City and Guilds of London Institute for encouraging more specialised knowledge, perhaps we might or ought, I think, to be able to which define as *scientific instruction with a bias in certain directions—viz., the Technological directions.* The *bias* is involved, of course, in the *application* of the science to the *modus operandi* and means adopted, for the realisation by utilising certain of its laws and facts, of produce on a large scale, a larger one for example, than that of the instruction workshop or laboratory. As regards the chemical industries, there is analogy then between the laboratory and the works, and since the proper construction and use of apparatus in the laboratory forms a phase of instruction inseparable from the learning of practical scientific chemistry, so in the case of chemical work on the large scale, the general principles of construction and use of plant and apparatus, must also form a phase of instruction inseparable from the learning of practical chemistry as carried on in the works. I am quite aware that other prominent conditions come in, in the latter branch, and are important, as economics, wear and tear, etc., matters based on long observation and experience, and for all these reasons, it must be plain that only a certain amount, and that not a very large one, can be taught in schools and colleges, of this subject of Technical Chemistry in the full sense. It is a subject for a life practice; but I hold most firmly, as I know by experience, that a certain amount can be taught and usefully taught, and further, that much more can be taught by those who have had at one time or another actual living experience in the works, just as practical and analytical chemistry can be taught best by those who have worked themselves in the laboratory, rather than by those with a mere book-knowledge of the methods used.

As to practical technical skill conferred by knowledge of general scientific principles amongst working-men and foremen, this might not be very specially manifested in some mere rule-of-thumb processes, supposing the workmen "*were* watched at their work"; the result of such instruction and training will be a general improvement, but nevertheless the "*power to do work*" must be conferred, for is not knowledge power, and power to do work? If, moreover, an objection to the examination scheme of the City and Guilds of London Institute is, that a large number of our present most experienced workmen are unable to express themselves in writing so as to give replies to the questions, we now see from what I have read from the Report of the Royal Commissioners, that the growing generation will not have that difficulty to contend with, and so the Institute will soon outgrow this defect, if it be one. I consider that the examination questions "such as may be put to elementary students in science, bearing upon the technological subject to which they refer, *without testing* the knowledge of technical details," if understood and answered, might be evidence of great good being done, and of a kind, were I the employer of the successful examinees, I should hail with delight; but to draw forth in public examination form from my workmen evidence on paper of a knowledge of technical details in some directions might excite my feelings in quite another direction. These details belong essentially to the works, and the teaching of applied science in the wide and true sense can flourish without them, *for it aims at growth of understanding, reason and intellect*, and not at accumulation of knowledge of special details.

References were made, not very favourably, in the November discussion to science examinations generally, and to those of the South Kensington or Science and Art Department especially, and the well-worn objection of so-called "cramming" was brought against them. It must be remembered, however, that the word *cram* can be only too easily applied. The mind cannot be stored with facts, without these facts being introduced somehow, and the substitution of the word *cram* for *introduce* is often too lightly made. Examinations must be passed, just as competition in business must arise, and just as races must be run in many ways, and in many spheres of work. Such competition is considered a healthy sign. But as regards this alleged "cramming" for Science and Art examinations at South Kensington let us remember some important statements on this head, by no less an authority than Professor Huxley, to wit, that when he looks back at the state of scientific ignorance in this country some thirty years ago, and then regards the present state of comparative enlightenment, he is astonished at the advance, an advance largely due to the effect of the study, reading and work in preparation for the continually recurring examinations of the Science and Art Department.

Now with regard to the first group referred to in the Royal Commissioners' Report—viz., the *Proprietors and Superior Managers*, and their instruction in Chemical Technology and the attendant or involved branches of science. You will have already read in the address of Sir Henry Roscoe at the opening meeting of the Manchester Section, in the number of our Journal for last December, what his views are on the subject of the higher education and training needed by this class, all of which I most cordially endorse. Especially would I call attention to Sir Henry's weighty words on page 594 (paragraph at foot of column one and top of column two), where he points to the highest platform, or school, needed by those who are to be our leaders in industrial science,—viz., that of *original research*, the search after new manifestations of laws and forces, or even after new laws and forces, for only by such search can the closest intimacy of acquaintance with the workings of these laws and forces be attained. Then as regards the wider general education necessary for this class, I would refer to the important words in Vol. I. of Rep. Roy. Com., pp. 515 and 516.

> "*Technical Instruction for Proprietors and Managers.*—In determining what is the best preparation for the industrial career of those who may expect to occupy the highest positions, it is necessary to differentiate between capitalists who will take the general, as distinguished from the technical, direction of large establishments, and those at the head of small undertakings, or the persons more especially charged with the technical details of either. For the education of the former, ample time is available, and they have the choice between several of our modernised grammar schools, to be followed by attendance at the various colleges in which science teaching is made an essential feature, or the great public schools and universities; provided that, in these latter, science and modern languages should take a more prominent place. Either of these methods may furnish an appropriate education for those persons to whom such general cultivation as will prepare them to deal with questions of administration is of greater value than an intimate acquaintance with technical details. It is different in regard to the smaller manufacturers and to the practical managers of works. In their case, sound knowledge of scientific principles has to be combined with the practical training of the factory, and, therefore, the time which can be appropriated to the former, that is, to theoretical instruction, will generally be more limited.
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> "*How Training may be Obtained.*—How this combination is to be carried out will vary with the trade and with the circumstances of the individual. In those cases in which theoretical knowledge and scientific training are of pre-eminent importance, as in the case of the manufacturer of fine chemicals, or in that of the metallurgical chemist, or the electrical engineer, the higher technical education may with advantage be extended to the age of 21 or 22. In the cases, however, of those who are to be, for example, managers of chemical works in which complex machinery is used, or managers of rolling mills, or mechanical engineers, where early and prolonged workshop experience is all-important, the theoretical training should be completed at not later than 19 years of age, when the works must be entered, and the scientific education carried further by private study, or by such other means as do not interfere with the practical work of their callings. Many colleges of the class to which we have referred have already arranged their courses to meet these requirements, and some of them, as will appear from our reports of visits, have workshops for the purpose of familiarising the students with the use of machine and hand tools."

Of course Sir Henry Roscoe in his address to the Manchester Section (*loc. cit.*) referred to our course of instruction in Chemical Technology in the Owens College in the examples given, and as it is in this course that my experience is mainly wrapped up, I may perhaps be excused if I refer to some details in connection therewith, which may be of interest and, peradventure, possess some points of novelty.

Although in many respects similar to, and to some extent planned from, the Polytechnikum course followed in Zürich, which curriculum I became familiar with after working there for three years as a teacher as well as a learner, an entirely new departure has been taken in our case having no parallel anywhere that I know of. This is, as I will as briefly as possible try to show, in the intimate and most advantageous connection established between the science degree course of the Victoria University and the course of Technological Chemistry.

It is possible for a student to set out for a four years' study at the Owens College, to make the preliminary course preceding matriculation in the University identical with and cover the preparatory year for the Technological Chemistry course, and at the end of the succeeding three years to conclude by passing the B.Sc. degree of the Victoria University with honours in Chemical Technology, and also to acquire the certificate (analogous to the Zürich Polytechnikum Diplom) in Chemical Technology. The advantages, to such a student are manifest. He leaves the college armed with the requisite knowledge for starting in life, either in the profession of teaching or in the technical direction, and he has credentials to smooth his way, and to help in opening up whichever path he may choose. If in addition to this the student could take the certificate of the City and Guilds of London Institute, that would be still further proof of fitness. But this requires time, and so did apprenticeships in older times—apprenticeships of seven years for learning a trade. Now let us see what the Owens College course in Chemical Technology involves, and mainly consists of. We have the *Preparatory course*, analogous to the Zürich Vorkurs in which no technology at all appears, for we assume that if we mean by Chemical Technology, Applied Chemistry, then there must be first present the *something to apply* before we can talk of its applications. Hence this first year is devoted to the Study of Inorganic Chemistry (the non-metals), Practical Chemistry (qualitative analytical work in the laboratory, with Analytical Chemistry lectures), Mathematics, Mechanics (lectures), Geology (stratigraphical), French or German, Geometrical Drawing lectures, Mechanical Drawing, practical.

In the *second year*, or *first of the Technological Course proper*, we have Chemistry lectures (non-metals and metals, or junior and senior), Chemical Laboratory (quantitative work), Technological Chemistry lectures (first course). Experimental Physics or Elementary Mineralogy, German or French, with the injunction that it is desirable the student by the end of the second year should have gained a knowledge of the elements of both these languages. Then come Geometrical and Mechanical Drawing lectures and practise, as in the previous year.

In the *third year*, the *second of the Technological Course*, the Senior Chemistry lectures are repeated, if desired. The Organic Chemistry lectures are now entered, with those on Chemical Philosophy. Moreover, as a practical course, the Physical Laboratory is also entered where the practical study of Chemical Physics is pursued, or as a matter of choice the Advanced Mineralogy lectures with a practical course in that branch may be entered. Mechanical Drawing is continued, but now without the Geometrical Drawing lectures, and it is continued to the end of the entire course, so important is it considered that this part of an engineer's training shall be undergone by the students of Applied Chemistry. The second course of lectures in Chemical Technology is lastly to be heard and to be passed.

The final year is devoted to the hearing and passing the lectures and examinations in Organic Chemistry a second time, unless they have been heard and passed in the former year. The Technological Chemistry lectures, two courses—viz., the third and fourth. Chemical Laboratory, four days per week, and Mechanical Drawing. But now you may desire to know what the Technological Chemistry lectures themselves treat of, and how they are graduated to the increasing proficiency in general scientific, specially chemical, knowledge of the student, moreover, what is done in the Chemical Laboratory? We saw that in the *First Year's Technological Course*, the Inorganic Chemistry lectures had already been heard, and now we have a course of applied Inorganic Chemistry, that of the sulphuric acid and alkali manufacture with the attendant branches, as much as there is time for. It should be stated that these courses are ended by visits to chemical works as far as possible, so that practical illustration of the principles involved in the courses of lectures are thus afforded. In this direction we number amongst our friends of the Liverpool Section, several, who give us annually most generous assistance by throwing open their works to our students, and who generally themselves explain the principles of their plant and processes to them.

In the second Technological Year, Organic Chemistry is just commenced, and some insight has already been obtained into it, in the closing lectures of the Senior Systematic course, and moreover the elements of Chemical Physics have also been learned, and now comes a branch of applied Chemical Physics with elementary Organic Chemistry, in the Technological Chemistry lectures, which are heard in this year. A. The destructive distillation of wood and the products obtained. B. The Chemical Technology of fuel, manufacture of coke with recovery of volatile products in coke ovens. C. The distillation of coal-tar, and separation of crude tar products, and ammonia and ammonium salts from gas-liquor.

In the third and final year a further demand is made upon the knowledge of Organic Chemistry, which should now be attained, in the third course of Technological lectures, on the manufacture of coal-tar products, intermediate derivatives and coal-tar dyes and colouring matters; and in the fourth course of lectures, both the knowledge of Organic Chemistry and that of Geometrical and Mechanical Drawing will appear in their full value, in the study of textile fibres, bleaching, dyeing and calico-printing.

As regards the laboratory courses, what is first insisted on is the mastery of systematic courses of qualitative and quantitative chemical analysis, and this before any serious attempt is made in the direction of preparations further than those afterwards employed for analysis. Now it will be said by some, a course of good preparations, or of experimental investigation into the working of fundamental chemical and physical laws, would be of more real service to a student who is to be a thinker, and an original thinker, than all these disciplinary courses of analytical work, already so "cut and dried," and tabulated. I would reply, " there is a time for everything," and after this course of manipulative analytical study is over, is the right time to commence to utilise all the means now acquired and at hand, for original research and investigation, either by means of preparations or original work.

But now to come to one of the difficulties with which such a high standard and course in England is encompassed; this is that its necessity is not sufficiently understood, and yet, so far as I have observed, all those who *have* persevered and *have* passed our full course, are now in good positions, positions proportionately higher to their superior merit.

There is no outlay of proportionately meagre amounts in any commercial branch, for which such, I would almost say, outrageously large and quick returns are demanded, as in Chemical Education in this country.

There is another difficulty, as regards getting admittance for the higher talent of our lower classes into the higher colleges.

However, we are looking forwards hopefully to lay the foundation of a grand system, and the outlook is a satisfactory one, but would be more so if we could only by means of bursaries or scholarships connect the board schools and the higher colleges. When such connection is effected, I should not be surprised to find that in the future, looking at the thoroughness of the teaching given, the managers and even heads of our industrial concerns will be rather supplied from the chosen spirits of board schools, than from the sons of the wealthier classes who have been sent to Eton and Harrow, etc.

In conclusion, it is pretty clear that the meaning of the word Chemical Technology receives often different interpretations, but the sense in which I have wished to use it and understand it, is to refer to the scientific principles involved in and encompassing the chemical industries, and in the use of means and appliances therein. I know it is nonsense to attempt to teach Chemical Technology, in the narrower sense, in colleges, but there is much that can be taught as already shown, and if the governing principles are taught by those who have lived and served in the factories, more vivid and true pictures and illustrations can be given, and the applications of the principles themselves better amplified and enforced. Nevertheless, so far as my own teaching is concerned, and especially in the branches in which I have had practical experience, it is certainly not behind the times. To be ten years behind, except in certain special branches, limited in number, would argue practical inexperience or negligence, or at all events that our Journal was not serving its purpose in educational directions. I quite agree that the technical text-books are mostly ten years behind, and often more. However, in teaching what I understand by Chemical Technology, it is not necessary to give all that is done absolutely up to date, nor to give full instruction in all that is done. The student's time is far too precious for the latter and too much occupied by the study of broad scientific truths; but the teachers would, or ought to, know how best to give the general outlines, and draw general lessons of scientific principle from what they have seen and know, so that the clothing with more minute practical details, proportions, and quantities would soon be put on hereafter, when the arena of actual working practice is entered. The mental training in generalising legitimately and logically from the smaller area of the laboratory to the larger spheres of working on a larger scale, if it be but by outline and on broad principles, properly carried out, is, I am certain, of the highest value to the student, in furnishing him with general maxims and data to help in clearing his way, assisting his vision and reasoning faculties, and giving him a readiness more quickly to adapt himself at the outset, on entering the works, to the new circumstances and scenes about him. This means, of course, to begin to be of real use to his employers in the shortest possible time after entering their service.

To turn finally to another point which has been mooted. Before the Society of Chemical Industry undertakes to *do something* to promote *sound instruction and examinations in chemical technology*, I should like to hear precise definitions of what these are to mean. Our Society, I take it, is doing pretty well in issuing an annual report of the advance of Chemical Technology in the shape of the Journal, which costs many of the members both of our council and the publication committee no little trouble and time. Our Journal is an ever progressing and progressive course of Chemical Technology itself, and both as a standard of the knowledge required, and as a means of instruction, it aims at doing a grand work, in which all its sections and each individual may participate.

DISCUSSION.

The Chairman was sure they were all very much indebted to Mr. Watson Smith for his admirable paper, and for bringing the whole subject so ably before them.

Mr. Henry Brunner: It seems to me that this question of scientific and technical education is a very large one, more especially as for every different part of our country the system of teaching, and certainly the direction of that teaching, cannot be the same. I think that science, even the most elementary, to be properly taught, ought to be taught by scientific men, and I object very much to this additional work being put upon teachers, such as school board teachers, because they have, as a rule, already too many subjects to teach, and to expect them to take science in addition would be a great mistake. With regard to what Mr. Watson Smith has said about The Victoria University and The Owens College, I am of opinion that they begin too young. A four years' course is very good, and ought to be ample if a student is sufficiently well prepared when he comes there to profit by it, but boys are admitted to the college, and they may commence this four years' course at fourteen years of age. I think that is two years too soon, and that they ought not to be admitted before they are sixteen years of age, because I do not think it possible for boys to take proper advantage of a comparatively severe course of scientific teaching at a time of life when their physical development requires so much care and attention. It seems to me we want something intermediate between our elementary schools and our scientific and technical schools such as The Owens College. What these schools are to be I do not know,* and from what little I have seen of the Blue Book containing the Report of the Royal Commission, there does not appear to be any suggestion for provision of schools of the kind, but it appears to be contemplated that boys should go from board schools—by which I understand elementary schools to be meant—to scientific and technical schools, and thence, perhaps, pass on to the universities. I want again to say that we are too anxious—or appear to be too anxious—to turn our young fellows of scientific and technical training out into the world too soon. When a young man has finished a course such as that provided by the Owens College, he ought to be able at once to take up in a manufactory or works a position where his knowledge would be of use to himself and to his employers. But at eighteen years of age he could not be put in charge of workmen simply on account of his youth. They would not listen to him. If a student finished his course at twenty or twenty-one it would be quite early enough.

Mr. Carey: I quite agree with what my friend Mr. Brunner has been saying as to the age of the boys when they begin this technical education. It is too early to take them immediately from the schools, and to, for instance, The Owens College, without distinguishing as to the class in which these boys are, and the future place they are to fill. We have to observe the distinctions which Mr. Watson Smith has spoken of; and which are also spoken of in the Report of the Commissioners—that is, the "workman and foreman" class, and the "manager and employer" class. It is quite obvious that there would be a very much wider education given in the latter case than could be possibly finished by a boy of 16 or 17 years of age I think the remarks of the Commissioners on page 516, vol. i., bear out what Mr. Brunner has been saying. They say:—

> "The best preparation for technical study is a good modern secondary school of the types of the Manchester Grammar School, the Bedford Modern School, etc. We consider it to be essential that steps should be taken to ensure that this work shall be carried on with greater vigour in the future than it has been hitherto. In the schemes for the new schools,

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[*] But I trust the necessity of physical training will not be so completely overlooked as it has been in our elementary school system.

the subjects of science and modern languages should form a very prominent part. But the existing endowments are unevenly distributed. In many of the large manufacturing centres no resources of the kind exist. Private enterprise is clearly inadequate to do all that is required in establishing such schools, and we must look to some public measure to supply this—the greatest defect of our educational system," etc., etc.

Referring to the subject generally, I would like to say that, with regard to Mr. Tate's paper, I do not agree with all his remarks. I think Mr. Tate proposes, if I understand him rightly, that we should give a detailed technical education to workmen, and to tell them, for instance, how to work furnaces, an education which can only be carried out, I think, satisfactorily in the works. With regard to the preparation for technical work, I agreed with Mr. Mond at the last meeting, when he said something to the effect that we should arrange matters so as to give a student a thorough scientific education, educating his faculties and then leaving the detailed technical work to the time when he gets into actual practical work in the factories. I think you cannot give a young man too wide an education, or one too thorough in actual science, but of course the direction which his scientific studies take must be with a view to the future, and the branch of technology he intends to pursue. I think it might be useful for us, as another text for our discussion, if we took the recommendations of the Royal Commission, and what they suggest should be done in the way of altering our present legislation for the purpose of improving technical education. I do not know whether it would be in order, sir, to discuss these recommendations one by one, to see if we can come to any action upon them, and whether we as a section are inclined to support them, or whether we have any suggestions to make in addition to the recommendations of the Commissioners, both with regard to elementary schools, and with regard to the higher education also. I do not know whether it would be in order now.

The Chairman: It is in order; and the only question is whether we should come to a definite resolution on the subject, from this Section. I do not know whether it would not be desirable, after discussing the question, that we should not possibly pass some resolution, because I presume if that were forwarded to the proper quarter, it would be some support to the recommendations of the Commission.

Mr. Carey then proceeded to read as follows:—

On page 517, vol. i., the Commissioners say:—

> "For the great mass of our working population who must necessarily begin to earn their livelihood at an early age, and from whom our foremen will be mostly selected, it is essential that instruction in the rudiments of the sciences bearing upon industry should form a part of the curriculum of the elementary schools."

On page 536 *et seq.* of the same volume, appear the general recommendations of the Commissioners, many of which appear to me to be of great importance—*e.g.*:—

> "I. As to public elementary schools.—(*a*) That rudimentary drawing be incorporated with writing as a single elementary subject, and that instruction in elementary drawing be continued throughout the standards, etc. (*b*) That there be only two class subjects instead of three in the lower division of elementary schools, and that the object lessons for teaching elementary science shall include the subject of geography.
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> "II. (*a*) That School Boards have power to establish, conduct, and contribute to the maintenance of classes for young persons and adults (being artisans) under the Science and Art Department. That in localities having no School Board the local authority have analogous powers. . . .
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> "V. (*a*) That ratepayers have power by vote to sanction the increase of the expenditure, under the Public Libraries Acts, beyond its present limit, and that the restriction of the Acts to localities having 5000 inhabitants and upwards be repealed."

In addition to the recommendations which necessitate action on the part of the legislature, or of the public authorities, there are suggestions made for the consideration of those in whose power it is to comply with them, such as:—

> "I. That it be a condition by employers of young persons, and by the trade organisations, in the case of industries for which an aquaintance with science or art is desirable, that such young persons requiring it receive instruction therein, either in schools attached to works or groups of works, or in such classes as may be available; the employers and trade organisation, in the latter case, contributing to the maintenance of such classes."

The recommendations which I have read—and they are only examples of many others of equal interest and importance made by the Commissioners—appear to me to give subject matter for serious consideration and discussion, and to be in the main recommendations which should be supported by our Society.

Mr. A. Norman Tate said that in opening the discussion at the November meeting, his object was more especially to call attention to the matter, with the view of moving a resolution that that Section should ask the Council to appoint a permanent committee, to take cognisance of what was now being done in this country to further instruction and examination in chemical technology, and to suggest from time to time improvements; and he thought the remarks that had been made that evening, especially those which had fallen from Mr. Carey, showed that such a course of procedure was desirable. He thought he might have been a little misunderstood in the remarks he had made at the November meeting. He certainly did not think it was possible by any systematic course of instruction in schools or colleges to teach workmen or foremen, employers or superintendents of works, all the technical details of any manufacture in which these persons might be engaged, but he did think they might go much further than at present in giving the power to carry on technical work. What was required first of all was a knowledge of facts, and he thought it was desirable to supplement the mere lecture instruction by a course which would bring out the power of observation to a greater degree. Mr. Watson Smith had spoken of the work done by the several instructors in the Liverpool, Manchester, and other Board Schools. He (Mr. Tate) had on two or three occasions had the pleasure of watching Mr. Hewitt, Chief Science Instructor to the Liverpool School Board, in his work of instruction in mechanics, and he put the elder boys through a course of instruction which could not fail to give them powers of observation which they could never have imparted to them by the study of the ordinary subjects of board school instruction. A boy after passing through such a course, if he went into a shipbuilding yard, a builder's yard, or workshop, would have implanted in his mind a knowledge of the principles of much of the work he would have afterwards to carry on. This was the sort of thing that they wanted carried on to a greater extent. Although this work was done in Liverpool, in Manchester, and in Birmingham, if they took other towns where there was a large number of workmen engaged in trades and manufacturing operations, they would find that the lads there left school and went into these manufactories without any such training. If a committee were appointed, one thing that could be done would be to issue recommendations to school boards in towns in which chemical industries were carried on, and point out what was done in other places, and keep them well informed of what was really useful in special technological directions. Then when they came to special studies, he noticed in the Blue Book a very excellent plan of training adopted in certain schools on the Continent. The older pupils were occupied some portion of each day in taking meteorological observations. Certain of them were set apart to take the temperature and barometrical pressure, etc., registering these in a careful manner. Now here pupils were trained in powers of observation, and what observations they made could be readily checked. This was one way in which the observing powers might be trained; and there were many others involving the working of simple processes only. A youth going into a chemical works, already trained to take temperature, specific gravity, etc., would often be more useful than the lads who now commence work in chemical manufactories and other industrial establishments. Another point to which he would call attention was, how far it might be desirable to introduce into this country, special schools, something similar to the apprentice schools that are in existence on the Continent. In vol. i. page 48, of the Commissioners' Report, there was a description given of these technical apprenticeship schools. There was much to be said in favour of such schools, either as taking the place of some of the apprenticeships which were in vogue in this country, or in supplementing them. In many of the technological colleges there was a want of grouping, especially in relation to chemical technology. It was all very well to give a student a knowledge of the general facts of chemistry, and of chemical analysis and power to make chemical analyses, and do other laboratory work; but there was wanted something more than chemical instruction, before chemistry could be made available for technological purposes. The student must have a knowledge of subsidiary subjects. How was it that so many of their chemical patents fell through? It was simply through a want of knowledge of the composition of the materials used in carrying out chemical operations and methods of putting them together. Therefore in addition to the knowledge of chemistry it should be insisted upon as a matter of chemical technology, that there should be a thorough knowledge of the building and other materials used, their quality and strength, and the manner in which they could be best utilised for certain purposes. Then again they should have a knowledge of mechanics and machinery. The most elaborate machinery might be designed and yet break down in chemical operations. He therefore could not look upon any course of instruction of chemical technology as complete, unless the student was compelled to study these subsidiary matters to a considerable extent of detail. He did not think that it was altogether impossible, in addition to ordinary laboratory work, that instruction in working experimental furnaces and other larger apparatus used in manufactories, might be given in good technical schools, and certain processes taught, such as, for example, modes of using to best advantage fuel, etc. Industrial museums would, he thought, prove highly useful, and it was to be hoped that the exhibition of inventions, etc., which was to take place next year in London would give them a considerable amount of information. They might do something towards establishing, in the centres of industry, technical museums. A technical museum, in a town like Widnes, would have a very good effect. It would show those who were growing up to enter the works what the substances used and products were that were manufactured in the town, and give them some idea of the general processes by which they were manufactured, and similar museums might be established throughout the country. It had been suggested that in Liverpool there should be a museum of casts; but at a meeting he had attended, when several artisans were present, it was considered by them that the money would be far better spent in a museum of mechanical inventions and contrivances, and the different kinds of woods and metals used in workshops. The remarks made at the meeting he referred to showed that workmen were quite ready to make use of exhibitions of machinery and industrial appliances, and learn from them as much as possible. He therefore thought that museums of raw materials used in chemical processes, and their products, with illustrations of machinery and apparatus used, would do much to further chemical technology. Then as regards prizes and scholarships, it might not be within the power, at present, of the Council to vote funds for special prizes, etc.; but something might be done, he thought, with good results, in offering prizes for special proficiency in chemical technology—something after the manner of the City and Guilds of London Institute. This Institute offers prizes of from £1 to £5, with medals, etc., for proficiency in certain subjects. On the same principle it might be possible to establish scholarships. He considered that examinations in technology were too much upon paper; and they ought to have some better test of the knowledge of scientific facts and certain general details. He thought the best examinations would be in seeing candidates while at work, either in firing a furnace or working black-ash, or testing the work in making some textile fabric,, and other really practical operations. Let the examinations be an actual test of the work done, and not the putting of certain printed questions to be answered on paper. He was still prepared to move that a committee be appointed to take cognisance of these matters.

The Chairman expressed a hope that some such a resolution as Mr. Tate had suggested would be passed. That Society might undoubtedly give support to any legislation that might be proposed for the improvement of technical education, and he thought Mr. Carey was quite right in considering the recommendations which the Commissioners had made. It was clear that the instruction given to workmen must be very different to that given to foremen and managers of works; but he thought it was very desirable that every workman engaged in chemical manufacture should understand something of chemistry, and some idea of the substances they were treating, and the behaviour of those substances, and the general laws which governed each. A stoker was all the better for knowing something of the laws of combustion. He did not see why elementary chemistry should not be taught in board schools, but he quite agreed with Mr. Brunner that science should not be taught by the ordinary school teachers. If they taught science at all, it ought to be taught in a proper manner. He thought the system adopted in Liverpool was a proper system, and he did not see why they should not have some such system at Widnes. The Royal Commission recommended that in rural schools instruction should be given in the principles of agriculture in the upper standards. He thought a similar thing should be done in a place like Widnes, and lessons given in the principles of chemistry, and so with other districts. But then they must go to something beyond mere elementary instruction. He thought it desirable to have the full course of instruction such as was given at The Owens College, where, so far as he had gathered, there was a most admirable curriculum. He agreed with Mr. Brunner that it would be far better for boys to enter such a college at the age of 16 and leave at 20, than to go at 14 and leave at 18. This curriculum had been in existence only four years, and he had not the slightest doubt after some years they would be able to improve upon the curriculum, but as far as it had gone it seemed to be a very efficient one. He was glad to hear Mr. Watson Smith quote from Sir Henry Roscoe, that after being taught analysis and chemical preparations, pupils should devote themselves to some kind of original research. This was most valuable. It would draw forth their powers of observation, and it would be the most useful part of their education to fit them to take part in chemical works. He was glad that Sir Henry Roscoe had come to the same conclusion as he had himself, and made the same recommendation. Nothing as yet had been done by the Government upon the Report of the Royal Commission, but he thought it would be very desirable and of great advantage if a society like that, as well as the Iron and Steel Institute and other societies, should press upon the Government the absolute necessity of taking steps to follow the Commissioners' recommendations.

REPLY.

Mr. Watson Smith : I entirely agree with Mr. Brunner's sentiments with regard to the advantage of the educational system of the board schools in different cities and towns, differing and varying as to degree or bias, both as regards kind and amount taught of the elements of Applied Science according to the nature of the staple industries of the cities and towns in question.

It is certainly desirable that mere boys should not enter the higher colleges too young, and in an unprepared state; their parents and guardians are sometimes too eager to send them early to college in order to take them away again too soon. I quite agree with the statement that they ought to go later, if that means *better prepared*, and stay longer, if that means *completing the educational course*, but I would like to add a word here: there are not a few who come not too young, but they come unprepared; *unschooled*, in fact. If such as these stay until old age advances they would scarce be able to recover what has never been gained at school. What I see great cause to complain of, is that amongst certain of our middle classes the question of the really sound, solid education of boyhood and youth in the schools, according to some rational plan, is not treated with sufficient earnestness. If something of the vigour, zeal and determination of purpose manifested in the various popular school games and sports, were *insisted on* in the mastery of even the lower elements of mathematics for those who are to study science afterwards in our colleges, then we should see fewer examples of young men utterly unable to rise in science, because almost incompetent to reason numerically, not to speak of mathematically. It is usually a grand blunder to assume or suppose—as I fear is often assumed or supposed—that an unschooled boy can make up his deficiencies at college; *as a rule, he cannot;* there are exceptions, *but they are few.* This blunder is one that is being continually made in this country; and it is the source of much perplexity to the teaching bodies of our higher colleges, much despair and disappointment when it is well-nigh too late to mend, to the student and his friends, *and of most of the failure of the young chemists of this country to compete with those of Germany.* Nearly all the energies and time of the teachers are consumed in teaching unfledged birds to fly, as it were; so that strength, time and opportunity are shortened for the very few capable of soaring aloft. This too usual and general state of things explains, moreover, a point very properly called attention to by Mr. Carey,—viz., that it should not be possible for board school boys, in a general way, to enter at all easily, and compete, in the courses of the higher colleges. In these colleges we have not, as in Germany, in the main to deal with our subjects, starting from a certain higher platform; but we have to cope with the drawbacks and disadvantages already prefigured, as far as we are able, by exercises, tutorialising, and the like. As an example may be mentioned what has already been openly styled, "chemical arithmetic," the great need of which is manifested in the numerous excellent little books published on the subject, which points—not so much to the difficulty of elucidating the chemical theories or the chemistry of certain experimental operations—as it does to an evident flaw in the previous systems of elementary mathematical instruction in the schools. Why, else, is it that such little books are never to be seen in Germany and Switzerland in connection with the universities and polytechnic schools? Our board school boys are taught to perform most of such calculations (at least in Manchester) with considerable ease, both in the branches of mechanics and chemistry. However, I believe I referred to *the chosen spirits of the board schools*; and since our lower class population is so vast, these "chosen spirits" may, peradventure, represent a respectable number. At The Owens College we have one small scholarship available in chemistry—viz., the "Crace-Calvert Scholarship," and only that one, and this available but once in two years. This is at the present moment held by a former board school scholar; and I am bound to say he is by far the best man of his year. With regard to Mr. Tate's motion in its *present* form, it seems to me both a practical and a good one; and I believe the reports furnished by such a committee would be valuable in a variety of ways. The technical practice Mr. Tate describes—in work likely to be of future value to ship-builders and similar workpeople—would be very well for Liverpool lads, just the thing for Liverpool, but the bias in Manchester must be in another direction—viz., that of chemistry, for in Manchester we have cotton bleaching, cotton dyeing, calico printing, and general chemical manufacturing, as our staple industries. However, I think I now see what one of Mr. Tate's objections to the City and Guilds of London Institute programme refers to,—viz., the lack of laboratory trials and examinations in connection with the questions set. It must be remembered though, that these examinations of the City and Guilds of London are thrown open free of cost to the country; and laboratory or workshop testing would entail vast expenses. Besides, if the theoretical side of the question is so grasped as to enable the candidates to pass these examinations, we need not complain; there is a lifetime to follow for utilising the theory in practice. With regard to the matter of what is termed "grouping;" this is done as I have already described in my paper; but it is done in subservience, as I hold it should be, with the student at college, to the main thing,—viz., the grounding and foundation in scientific principles. I believe the subject of strength of materials, and so on, is touched upon in the Geometrical Drawing lectures in our College; and as regards the further one of the chemical technology of building materials, mortars and cements, etc., this would be all very good for the practical engineer. However, our course of Chemical Technology in The Owens College is growing yet, and we have youth on our side, for our course was but founded in 1881. As to testing by examinations in technology taken in the narrower sense, such, *e.g.*, as examining a man on soda making, and then setting him to make a black-ash ball, and watching him do it, there I differ with Mr. Tate. Where the examination elicits evidence of general grasp and knowledge of scientific principles, there I follow; but where the mere manipulative skill, or the more specialised details, besides conscientious working and moral principle, are concerned, there I am sure we cannot intrude. As regards alkali making, moreover, in which there are no special secrets, even such manipulative competitions might be conceived possible; but take another branch, that of dyeing, or of the manufacture of dyes and colours, and there, I imagine, there would be a difficulty, for no dye house or dye and colour factory, that I know of, would permit such a thing; and for a workman to enter into such competition would be regarded probably with sufficient suspicion by his employers as to secure for him the wide world to hunt in for a new post in which to exert his prowess. In answer to remarks by Mr. Alex. Watt, I do certainly consider that there is scientific principle involved in the making or manufacturing with certain regard to economics, and as both logic and political economy are scientific branches, so the economies of the manufacturing industries admit of scientific treatment. Such treatment is absolutely necessary, and I do not overlook its principles, by any means, in my teaching. Without bestowing some attention to these, how could one else elucidate the mysteries of the occasional practical reversal of the terms "chief products" and "by-products." In science, the key-note is, so to say, "truth for its own sake;" in technology, it modulates into "truth for the largest amount of tangible profit it can be made to yield." I fear that if the group of possible technical subjects were swelled by too many reinforcements, then chemical technology, as a study, would rise from being the handmaid of science for the student, to the position of the tyrant; and the grasp of scientific truths, and the march in the right path of acquirement of fundamental truth and laws, would be weakened and hindered by excess of technicalities, which could all be gained and learned in the life and practice of the future, when, however, the time for studying and learning scientific principles has fled. I think I read in the extract from the Report of the Royal Commissioners that the teaching of science in the board schools is not mainly delegated to the board school teachers; it is not so in Liverpool, Manchester or Birmingham; but these teachers hear the teaching of the chief instructor, and then help the pupils, in what they, as older and more experienced persons, have learnt and understood to better purpose than the children, their pupils have.

I am not sure if stress has been laid by the Royal Commissioners on the technological bias, if I may use the term, to be observed in different industrial districts; but from their report it is clear that this has followed as a natural consequence in Liverpool, Manchester and Birmingham. No doubt such data as these could be usefully collected and applied by a committee appointed by our Council, such as that proposed and under consideration.

It was then moved by Mr. TATE: "That this Section recommend the Council to appoint a Committee for the purpose of considering the subject of Technical Instruction, and taking such steps as may be deemed advisable to promote more of such instruction in this country, especially as applied to Chemical Industry."

Mr. CAREY seconded, and the motion was carried unanimously.

Manchester Section.

Chairman: Sir H. E. Roscoe.
Vice-Chairman: D. B. Hewitt.
Committee:

R. F. Carpenter.
C. Estcourt.
H. Grimshaw.
Peter Hart.
J. von Hohenhausen.
T. Jackson.
J. Knowles.
I. Levinstein.
C. Schorlemmer.
Watson Smith.
Wm. Thomson.
D. Watson.

Local Secretary:
J. Carter-Bell, Bankfield, The Cliff, Higher Broughton, Manchester.

Notices of papers and communications for the meetings to be sent to the Local Secretary.

Meeting held Tuesday, January 20, 1885.

DR. HEWITT IN THE CHAIR.

THE CHAIRMAN: Words fail to express the feelings of all who have been placed in a similar position to that which Sir Henry and Lady Roscoe have so recently been called upon to endure, in the very sudden decease of one in whom their hopes were centred; and as I am sure there are many present who have realised those feelings, it will not require any lengthy explanation on my part in asking you to pass a vote of sincere condolence and sympathy with Sir Henry and his family, in the loss which they have sustained in the death of their son. I had not the pleasure of knowing Sir Henry's son, but I am informed that he promised to attain distinction in a somewhat different sphere from that in which his eminent father has become so well known, and that he has been cut off in the springtime of life and promise, adds bitterness to this deep bereavement. I will, without further comment, move the following resolution:—"This meeting desires to express sincere condolence and sympathy with Sir Henry and Lady Roscoe and their family in the sad bereavement they have sustained in the loss of an only son and brother."

Mr. WM. THOMSON, in seconding the vote of condolence, said: After attending the meeting of the British Association a few months ago in Canada, I saw Sir Henry's son at the Falls of Niagara, when he seemed to be in the enjoyment of robust health, and of the wonderful Falls, in the vicinity of which he remained during several days. I understand it was not his intention to follow in the footsteps of his father as a man of science, but in another direction he had already shown marked ability in a series of very cleverly written articles which appeared during last autumn in one of our Manchester newspapers, entitled, "Jottings from America," and which many of us must have read with pleasure. The loss which Sir Henry and Lady Roscoe have sustained by the untimely death of their only son, when he was about to enter on a career of the highest promise, is one with which we must all deeply sympathise.

The CHAIRMAN called attention to the "Rivers Pollution Bill" which had been introduced into Parliament, and which has come before the London Section, and said: It is hoped that the members of the Manchester Section will prepare themselves by obtaining all the information they can that will throw any light upon the matter, so that it may be fully discussed. It is a matter which will affect every manufacturer, and although of a practical nature, it is a subject upon which scientific knowledge must be brought to bear. I think it is the intention of the Committee to put it upon the notice paper for the next meeting, and any facts that can be adduced will be of the utmost importance. There is no doubt that this Society, consisting as it does of practical men, will have to make in its joint capacity some important reports to the Government on the matter. I need not say that any one who wants information upon the subject can find it in the voluminous reports which have been made to Parliament in former years. Some of the proposed tests of purity which were brought before the Rivers Pollution Commission on former occasions, and which proved to be impracticable, are again being introduced just as if no inquiry had been made. I hope that all who can will make some contribution to the subject, not merely for the sake of opposition, but for the purpose of showing whether it is possible, without interfering with trade or manufacture, to render our rivers more sightly and purer than they are at present.

Dr. Bott's Paper on "Hempel's Methods of Gas Analysis," and Prof. Wanklyn's Communication will appear in the March number.

Newcastle Section.

Chairman: J. C. Stevenson, M.P.
Vice-Chairman: B. S. Proctor.
Auditor: N. H. Martin.
Committee:

P. P. Bedson.
G. T. France.
C. H. Gimingham.
John Glover.
A. S. Herschel.
John Morrison.
John Pattinson.
H. R. Procter.
W. W. Proctor.
J. F. Stark.
T. W. Stuart.

Local Secretary and Treasurer: J. T. Dunn, 115, Scotswood Road, Newcastle.

Notices of papers and communications for the meetings to be sent to the Local Secretary.

Next meeting, March 5.—1. On the Proposed Statue to Nicholas Leblanc; 2. On the Recovery of Sulphur from Alkali Waste; 3. On a Furnace for Chemical Operations which is neither an Open Furnace nor a Close Furnace; and 4. On the Manufacture of Chlorine from Oxychloride of Magnesium. By Walter Weldon, F.R.S.

Meeting held, February 12, 1885, *in the Lecture Theatre of the Durham College of Science.*

MR. B. S. PROCTOR IN THE CHAIR.

DISCUSSION ON THE NOTES READ AT LAST MEETING.

MR. MORRISON wished Dr. Lunge had stated the size of the pieces of metal operated on in studying the action of chlorates on them, and how their surface was determined. In multiplying the results to the actual size of the evaporating pans, any error would of course be greatly increased.

Mr. TATTERS expressed his agreement with what Mr. Morrison had said.

Mr. STUART thought that Dr. Lunge's well-known accuracy and skill might be relied on to avoid error wherever it was possible. It was, however, very difficult to imitate exactly the conditions of manufacturing operations in laboratory experiments. As a matter of fact, it was known that the pans suffered very little in practice.

Dr. SMITH mentioned that in some very similar experiments which he had conducted in Dr. Lunge's laboratory, pieces of metal were used exposing a surface of about 20 square cm., and were accurately measured by a skilled mechanic.

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DISCUSSION ON THE "RIVERS POLLUTION BILL."

THE CHAIRMAN, in introducing the matter, regretted the unavoidable absence of the Chairman of the section, who would have spoken with authority on the matter. He called attention to Clause 26, and to the penalty in Clause 3, which he said applied to every household drain; and also to the loose wording of Clause 9, which made it appear that to escape prosecution under the Act, liquids must contain more than the quantities of the various contaminations mentioned. These were evidences of want of care in drawing up the Bill, and in dealing with a subject of so great importance, the greatest care was necessary. He then called on

Mr. JOHN PATTINSON, who said: The "Rivers Pollution Bill," which will probably be introduced into Parliament during the next session, and which we are called upon to discuss this evening, is a measure intended to supersede the Rivers Pollution Act of 1876, which has been comparatively a dead letter since its enactment. The present Bill is intended to remedy some of the defects of the 1876 Act as to methods of procedure, and also as to the definition of what in certain cases constitutes an offence under the Act. These defects have been described by Mr. C. N. Cresswell, in opening the discussion on this subject at the meeting of the London Section of this Society on the 5th of January last. Divested as far as possible of its legal verbiage, the scope and aim of the proposed Act appear to be as follows: In Clause 2 are defined what are to be considered as offences against the Act. In the first place it is an offence to put into a stream any solid matter so as to interfere with the due flow of the stream or alter its bed or pollute its waters, or to put in any solid matter which is putrid, poisonous, offensive or injurious to animal life. Secondly, it is an offence to put liquid or solid sewage matter into any stream: and thirdly, it is an offence to put into any stream any liquid containing matter poisonous, noxious, polluting, or injurious to animal life. In Clause 9 the Bill defines the term "stream" to mean that it "includes all rivers, whether tidal or otherwise, brooks, navigable canals, lakes and watercourses, except such parts of a tidal river as the Local Government Board may by order, published in the *London Gazette*, after local inquiry, determine on sanitary grounds not to be part of a river. It shall also include so much of the sea as the Local Government Board may by like order, and on the like ground, declare to be part of a stream." Having defined the offences under the Bill, it provides in Clause 5 that on the complaint of any conservancy authority or fishing board of the district, or of any occupier of land or a dwelling-house within the district, the sanitary authority of the district shall institute proceedings to restrain the commission of offences against the Act. If the sanitary authority refuses to institute such proceedings, or does not prosecute them with due diligence, the complainers may apply to the county court of the district for leave to institute proceedings themselves, and to prosecute them at the cost of the sanitary authority. Proceedings may also be instituted by any person who may consider himself aggrieved by the commission of offences against the Act. In the latter case it is provided that the Court may order the person who institutes the proceedings to give security for the costs of such proceedings. Persons of the latter class are further encouraged to institute proceedings against alleged offenders by clause 3, which provides that the offender "shall pay to the person complaining, or to such other person as the court may direct, such sum not exceeding fifty pounds a day for every day during which he is in default as the court may order." In case of proceedings being instituted for any alleged offence against the Act, Clause 3 provides that the county court may by summary order require any person to abstain from the commission of such offence, and "may direct any skilled persons to report as to the best means to be adopted for preventing any pollution, and may make the adoption of such means by the person who has committed the offence part of its order: provided always that the court shall not sanction the adoption of any mode or means of action for prevention of pollution that does not reduce the polluting matter to a less extent than is defined by the standards of purity" given in Clause 9. It is not very clearly so stated in any part of the Bill, but I think the inference may be fairly drawn that no liquids of any kind are to be allowed to be put into a stream which are less pure than the standards given in Clause 9. The standards of purity are those recommended by the late Royal Commission on the Pollution of Rivers. Some of these in my opinion are too lax and some are too rigid and exacting. Clause 4 gives the right to either party in an action to appeal against the decision of the county court, and Clause 6 gives the right to apply to the Local Government Board for an extension of the time allowed for adopting methods for the remedying of pollution. Such is a brief description of the principal features of this Bill. It will be seen that it is a very sweeping and stringent measure, and that, if passed in its present condition, it is likely to press very seriously not only upon many manufacturers, but even upon householders of every class. According to Clause 8, every person who sends sewage matter through his house-drain into a sewer, and from thence into a stream would be infringing the Act, and would be liable to a penalty of fifty pounds, and ten pounds a day for every day he thus uses his drain, if it has been made since 1876, and if the stream is not such part of a tidal river as "the Local Government Board may determine on sanitary grounds not to be part of a river." Surely this is far too stringent a clause to be placed at present on our statute book. The inducements held out by the 3rd and 5th Clauses are likely to cause litigious and needy persons to commence harassing legal proceedings against manufacturers and others, and this seems to me to be an objectionable feature of the Bill. The proposed Bill, if passed, would press most disastrously on many owners of mines, and on many manufacturers. To comply with its requirements, owners of mines and collieries would have to provide, in many cases at great cost, subsidence tanks and subsidence reservoirs. To enforce such a measure in the present condition of mining and manufacturing would in many cases be tantamount to closing the mines or manufactories altogether. I have had much experience in the methods of dealing with the waste waters of paper works, and am well acquainted with the degree of purity which can be attained in these waters by the application of the best practicable means. I have no hesitation in saying that if the standard of purity given in Clause 9 *a* of this Bill were insisted upon in the case of these out-flow waters, and if the penalties were enforced, no paper mill could continue to exist. In many other cases there are slight and sometimes considerable discharges of comparatively innocuous matter from manufactories, in which it would be very difficult, if not impossible, to comply with the requirements of this Bill. A boiler could not even be sludged out direct into a stream without incurring the severe penalties of this proposed Bill. On the other hand, some of the standards of purity are far too lax. Standards *h* and *i* are of this character. To allow liquids possessing an acidity equal to that which is produced by adding two parts by weight of real muriatic acid to one thousand parts by weight of distilled water, or possessing an alkalinity equal to that produced by adding one part by weight of dry caustic soda to one thousand parts of distilled water, is to allow the admission of liquids which would cause certain and immediate death to all animals which might come within their influence. I have prepared solutions of hydrochloric acid and caustic soda of the prescribed strengths, and the members of the Section will have an opportunity of noticing how very much stronger these are than any liquids should be which are allowed to be run into a stream under most circumstances. The great fault of the Bill, in my opinion, is its rigid and unyielding character. It makes no allowance for the varying conditions of the towns, and the varying character of the manufactures, and the streams with which it has to deal. It appears to me that the courts which have to adjudicate on alleged cases of pollution should not be bound down by the rigid conditions and standards of purity of this Bill, but that they should have the power of dealing with each case on its merits, and of insisting upon the adoption of the best known practicable means of preventing pollution. It is incumbent on every one likely to be prejudicially affected by this proposed measure to endeavour to get it modified before it passes into law, and I think the various sections of the Society of Chemical Industry are acting wisely in calling attention to the matter. I beg to move the following resolution:—"That this meeting of the Newcastle Section of the Society of Chemical Industry, being of opinion that the proposed 'Rivers Pollution Bill' is inadequate to the objects of its promoters, and injurious to the interests of manufacturers, recommends its early consideration by the Council of the Society, with a view to such action on its part as the interests of Industrial Chemistry may require."

Mr. T. W. STUART: I have great pleasure in seconding the resolution. The Bill will press very hardly on manufacturers and mine-owners. The standards of purity are such as in many instances cannot be worked up to.

Mr. JOHN MORRISON: What has struck me most is Mr. Crookes' proposal, mentioned by Mr. Cresswell, that each river should form its own standard of purity; that seems to me to be the best form the measure could take.

The resolution was then put to the meeting, and carried unanimously.

Birmingham and Midland Section.

Chairman: Alexander M. Chance.
Vice-Chairman: W. A. Tilden.
Committee:

G. S. Albright.
Horace T. Brown.
G. S. Casson.
J. F. Chance.
F. C. Clayton.
L. Demuth.
G. Gore.
R. Heathfield.

C. O'Sullivan.
L. Percival.
R. Peyton.
J. H. Player.
C. T. Ryder.
G. Shaw.
W. Southall.
W. A. Wiggin.

Hon. Treasurer: Charles Hunt.
Local Secretary:
A. BOSTOCK HILL, 14, Temple Street, Birmingham.

Notices of papers and communications for the meetings to be sent to the Local Secretary.

Glasgow and West of Scotland Section.

Chairman: Ed. C. C. Stanford.
Vice-chairman: J. Ferguson.
Committee:

George Beilby.
A. Crum Brown.
T. Carnelley.
J. Christie.
John Clark.
W. Dittmar.
Geo. M'Roberts.
Jas. Mactear.

E. J. Mills.
James Napier, jun.
T. L. Patterson.
J. B. Readman.
Edmund Ronalds.
F. J. Rowan.
R. R. Tatlock.
William Wallace.

Hon. Treasurer:
J. J. Coleman, 45, West Nile Street, Glasgow.
Local Secretary:
G. G. Henderson, Chemical Laboratory,
University of Glasgow.

Notices of papers and communications for the Meetings to be sent to the Local Secretary.

A Meeting of this Section will be held in the Rooms, 207, Bath Street, on Tuesday, 3rd March, at 8 o'clock P.M., when Mr. James Murrie will read the following papers:—(1.) "On the Processes employed in Italy for the extraction of Oils, etc., from bituminous rocks in that country." (2.) "Description of a series of New or Improved Thermometers for taking High Temperatures."

A meeting of this Section was held in the Rooms, 207, Bath Street, on Tuesday, 3rd February, 1885.

MR. E. C. C. STANFORD IN THE CHAIR.

ON BROMINE ABSORPTIONS.

BY EDMUND J. MILLS, D.SC., F.R.S.; AND JAMES MUTER.

IN two previous communications to this Society (*Journal* 1883, 435; and 1884, 366), a series of constants of Bromine Absorption has been tabulated for a variety of oils and fats. In the present paper we give results for most of the important resins, for a few elements, and some interesting bodies of a different nature.

Throughout our work we have felt no personal ill effects arise from a few days' use of carbonic disulphide; accordingly we have employed it or carbon tetrachloride indifferently, as happened to be convenient; it being probable from certain experiments that, when small quantities of substance are taken, the absorption is almost always the same in either solvent. We have, however, indicated in all cases which solvent has been employed.

As regards resinous bodies, we found it best to proceed as follows:—The finely-powdered resin was placed overnight (together with the usual 50cc. of solvent) in the colorimetric bottles, and the next morning the bromine absorption was carried out. Sometimes β-naphthol was used for "titrating back;" more particularly—as in the case of pale resins—when the bromine derivatives had but little tint. Sometimes the operation was finished with hyposulphite (thiosulphate) and decinormal iodine, and sometimes the purely colorimetric comparison alone was employed. Except where otherwise stated, all the results are means of at least three determinations.

The letters S. and L. indicate that disulphide or tetrachloride was used respectively. The letters N., H. and C. indicate that the absorption was finally measured by β-naphthol, hyposulphite or simple colorimetry. In nearly all cases the time of contact with bromine did not exceed an hour.

The names marked (*) represent commercial varieties of dragon's blood.

It will be observed that our experiments are divided into three groups, relating to (1 to 14) varnish resins, (15 to 34) tinctorial resins, (35 to 38) elements, (39, 40) oils.

The following substances gave no absorption in tetrachloride:—Benzoic, cinnamic, and salicylic acids; camphor, naphthalene and benzaldehyde.

The results with anthracene in tetrachloride were very peculiar. At 11° C., and with very cautious addition of standard bromine, the absorption was 88·67 per cent.; corresponding well with the ratio, $C_{14}H_{10} : Br_2$ (89·89 per cent.). At about 17°, the reaction was violent; much hydrobromic acid came off, and the absorption was 175·33 per cent., corresponding approximately with the ratio $C_{14}H_{10}Br_4$. (179·78 per cent.).

Some interesting features are noticeable in the tabulated results. Thus, the extraordinarily low absorption of shellac gives it a unique position among resinous bodies; and gum amber is distinctly below all other substances of its class. "Boiling" makes a measurable difference in copal; from which, again, kauri differs greatly. As a rule, but not invariably, the more soluble a gum resin, the greater is its bromine absorption.

For samples of all the tinctorial resins, excepting gamboge, we were indebted to Messrs. Dobbie and Henderson, who were at that time themselves investigating them from another point of view. Our bromine absorptions amply support their conclusion (*Pharm. Journ.*, Nov. 10, 1883), that the term "dragon's blood" represents several fundamentally distinct resins. *The same may be certainly said of the* xanthorrhœa resins.

As regards elementary bodies, it is remarkable that tin dust will not take up bromine in presence of carbon tetrachloride. The absorptions for commercial arsenic and aluminium are very peculiar, and would well repay further examination. Zinc dust takes up bromine in the proportion $Zn : Br_2$ (calculating 24·65 per cent. for pure zinc); and antimony in the proportion $Sb : Br_3$ (calculating 200·00 per cent. for pure antimony, our commercial sample apparently containing about six per cent. of impurities).

Aniline and Toluidine.—The great technical importance of these amines has induced us to devote special attention to them. It has already been shown (*loc. cit.*, 1883), that aniline, dissolved in carbon disulphide, absorbs bromine in the ratio $C_6H_7N : Br_2$. It is probable, in this case, as in that of the toluidines, that "additive" and not "substitution" compounds are formed. Our experiments with the toluidines relate to ortho- and para-toluidine only. Aniline oils contain very little meta-toluidine.

Para-toluidine.—This is the solid modification. The specimen had been prepared by one of us for a research on melting-point, and could be completely depended upon. Taking disulphide for the solvent, a standard solution of bromine, containing ·0115grm. in 1cc., and a weak standard solution of toluidine (in order to save repeated weighings), we found the results very irregular, and on the whole much too low, when quantities exceeding ·04grm. were employed. With that amount and under, the mean of three experiments gave an absorption of 74·47 per cent., with a probable error of ·18. This is in accordance with the ratio $2C_7H_9N : Br_2$, which requires 74·77 per cent. We also made a series of experiments with tetrachloride as the solvent, varying the strength of the standard bromine from ·0093grm. to ·0032grm. per cc., and the weight of toluidine from ·01grm. to ·03grm. The mean of five absorptions was 81·03, with a probable error of ·42. The chemical activity of para-toluidine in carbon disulphide is clearly less than in the tetrachloride; in the latter solvent, larger quantities than ·03grm. always seem to yield yellow by-products. It is evident that in this case the disulphide is a more advantageous solvent for analytical purposes.

Ortho-toluidine.—For this liquid modification we took ·025grm. toluidine, disulphide as the solvent, and standard bromine containing ·00483grm. in 1cc. The mean of six experiments gave an absorption of 151·34 per cent., with a probable error of ·53. The ratio, $C_7H_9N : Br_2$, requires 149·53 per cent. Our specimen, obtained from Kahlbaum, may possibly have contained a little aniline; but the difference from theory is only about 1·2 per cent. on the percentage. The chemical difference between ortho- and para-toluidine is very striking.

Mixtures of Aniline with Para-toluidine.—If the bromine absorption of a mixture of aniline with toluidine be known, the composition of the mixture admits of ready calculation. The quantities of mixture which we took were ·02 or ·025gm., the solvent being disulphide. Each result is a single

No.	Substance.	Absorption.	Remarks.
1	Shellac bleached....................	4·61	S. N. Chiefly insoluble.
2	Shellac..............................	5·21	S. N. Chiefly insoluble.
3	Gum Benzoin	38·90	S. N. Partly soluble. Some hydric bromide given off.
4	Amber	53·53	S. C. Partly soluble. Some hydric bromide.
5	Animé	60·22	S. N. Partly soluble. Much hydric bromide.
6	Gamboge	71·56	S. N. Chiefly soluble. Much hydric bromide.
7	Copal, reduced to ⅔ by boiling	81·52	S. N. Partly soluble. Much hydric bromide.
8	Copal................................	89·93	S. N. As above.
9	Sandarac	96·12	S. N. Partly soluble. Very much hydric bromide.
10	Kauri	108·22	S. N. Partly soluble. Some hydric bromide.
11	Thus	108·51	L. N. Chiefly soluble. Very little hydric bromide.
12	Dammar............................	117·91	S. N. Wholly soluble. Much hydric bromide.
13	Elemi	122·23	S. N. Wholly soluble. Very much hydric bromide.
14	Mastic	121·33	S. N. Partly soluble. Much hydric bromide.
15	Xanthorrhœa, New Holland	7·11	L. H. Slightly soluble.
16	Xanthorrhœa	8·33	L. H. Insoluble.
17	*Calamus	8·37	L. H. Insoluble.
18	X. hastilis (grass tree), Queensland	9·11	L. H. Partially soluble.
19	Xanthorrhœa, Australia	10·35	L. H. Partly soluble. A little hydric bromide.
20	*C., Punjaub........................	10·15	L. H. Insoluble.
21	*C., Kew............................	11·97	L. H. Insoluble.
22	*Dracœna Cinnabari, Socotra......	13.81	L. H. Insoluble.
23	X. hastilis, Australia	15·68	L. H. Insoluble.
24	*C. draco, Bombay	22·01	L. H. Insoluble.
25	X. hastilis, Tasmania	30·71	L. H. Insoluble.
26	X. hastilis, Sydney	33·25	L. N.
27	X. Preissii (Black Bay gum), W. Australia	36·93	L. H. Insoluble.
28	C. draco, Kew	55·21	L. H. Insoluble. Partly bleached by bromine.
29	*Sumatra	65·39	L. H. Partly soluble. Partly bleached.
30	*C. draco, Singapore	73·81	L. H. Partly bleached.
31	*Calamus, Menier & Co............	71·58	L. H.
32	*Dutch E. Indies	81·59	L. H. Insoluble: bleached.
33	*Sumatra	81·87	L. H. Partly soluble. Partly bleached.
34	Tin.............	0·00	L. C. No absorption in twelve hours.
35	Arsenic	2·85	L. H. Twelve hours' absorption.
36	Aluminium	8·97	L. N. One hour's absorption.
37	Zinc	22·17	L. N. Twelve hours' absorption.
38	Antimony	187·73	S. C. Nineteen hours' absorption.
39	Sunflower oil	51·45	L. S. C. N. (1881). Sp. gr. ·9215.
40	Haddock liver oil	109·81	S. C. (1881).

determination, carried out colorimetrically, except in the last case, where we give the mean of three experiments :—

TAKEN.		FOUND.		Bromine.
Aniline.	Toluidine.	Aniline.	Toluidine.	
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
25	75	21·66	75·31	98·90
40	60	45·98	51·02	119·60
50	50	48·37	51·63	121·90
60	40	61·11	38·86	131·32
75	25	72·06	27·91	141·90
90	10	88·95	11·05	161·32

The probable error per cent. of a single comparison of theory with experiment is, for either amine, 1·93; for a mean of three determinations (which we always recommend to be made), 1·11. There has apparently been some experimental slip in the work on 40 to 60 per cents., and we have excluded it from the calculation. With ten per cent. only of aniline, we have never been able to obtain satisfactory results. In such a case we should advise distilling off rather more than the aniline, and analysing the distillate and residue separately. As regards the analysis of mixtures of aniline and the two toluidines, all that is now required to complete the solution of the problem is a knowledge of the amount of some other element or compound with which these bodies combine. One of us is at present engaged with the investigation.

We wish to express our thanks to Messrs. Akitt and Ellis, who have given us very valuable assistance in the course of our work.

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THE PROPOSED RIVERS POLLUTION BILL.

Mr. E. C. C. Stanford said: Before I call on Professor Mills to open this discussion, perhaps I ought to explain that the Council of the Society has communicated with us, and recommended that we should devote an evening to the consideration of this extremely important subject. There seems to be a pretty general consensus of opinion that the proposed Bill is so *stringent that it is likely to defeat* its own objects.

The London Section has already held a long meeting for the discussion of this question, and has passed a very important resolution condemning it out and out.

I shall say no more at this stage, because I know that the great standards of purity, referred to in this Bill, will be brought before you by one of the most able authorities on this subject—namely, Professor Mills.

Professor Mills, in opening the discussion, said: In the November number of the Society's Journal (1884), the attention of the Sections has been called to a "Rivers Pollution Bill," prepared and brought in in November last. The Council of our own Section arranged that the Bill should be considered to-day, and it has fallen to my lot to open the discussion.

In the first place, I think we must all have noticed from time to time the growing interest taken by the public generally in sanitary matters. Part of this is doubtless due to the now well-established connection between disease and certain insanitary conditions; part to the ceaseless lawsuits between manufacturers and landed proprietors; and part to the undoubted success of the Alkali Act. Anyone who watched the state of the popular mind during the recent outbreak of cholera, must have noticed how much more intelligent it has become of late years; and we cannot be surprised that the framers of this Act should have supposed that the time was ripe for legislation.

The scope of the Act is very wide. It extends to all inland waters having a current, to canals, and even to estuaries: all these it forbids to be polluted by sewage or by effluents from manufactories of whatever kind, and the net of the penal clauses has been made capacious enough to enclose contributories to a pollution, even if their contributions have been in themselves perfectly harmless.

Up to the present time we have succeeded in devising processes for precipitating colouring and other matters, in removing chromates and arsenic, in preventing too great an acidity or alkalinity of an effluent, and so on. Tar is seldom or never at present a source of pollution, and a great deal of greasy matter and spent soap are now recovered. This shows us what may be done, and that in a large number of cases manufacturers have nothing to fear. On the other hand, they have much to hope; because a really efficient Act, applied to all alike, would improve the water supply for every one of them.

Following the pattern of the Alkali Act, this Act purposes to set up standards representing limits of pollution. It is quite clear that the principle of standards must necessarily be applied in any Act really worth having. Every one in fact in his daily purchases, and other social transactions, sets up more or less consciously a large variety of standards of value. We do *not* eat butter *perceptibly* rancid, or drink milk that is obviously sour. It is the business of sanitary science to lay down the precise boundaries, which in no case we should be allowed to overstep.

The numerical standards of the Act are the standards of the late Rivers Pollution Commission. Taking them as a whole, my impression is that they are extremely liberal. There is little, if any, ground of complaint in restricting an effluent to (*c*) be colourless in a layer one inch thick; (*d*) to contain less than two parts dissolved per 100,000 of any metal except calcium, magnesium, potassium, sodium; (*e*) less than ·05 of *metallic* arsenic in combination or otherwise; one part of (*g*) sulphur as sulphide; or (*k*) less than ·05 part of hydrocarbon oil. Probably most of the differences of opinion would have reference to the remaining standards. These I will now consider.

(*a*) The *dry organic matter* is not to exceed one part *in one hundred thousand. This standard is, in my* opinion, insufficiently defined. It presumably means loss on ignition after drying at 100°. But that loss is certainly not all organic matter. It would be better to use the term "loss on ignition of the dry solid residue," and state exactly by what method the loss should be determined.

(*b*) *Organic carbon and nitrogen.* The former is defined by the Rivers Pollution Commissioners to be "carbon contained in the organic matter" of a water. The proposed Act limits its amount to two parts. It need hardly be said that no *potable* water ever contains this enormous amount. The limit, in fact, suggested for this by the Commissioners was only 0·2 part.

The method of determining organic carbon proposed by Frankland is, undoubtedly, not of the simplest character. It requires the evaporation of the water under specially maintained conditions, the combustion of the residue in a vacuum, and an analysis of the gases thereafter collected. A good deal of work is thus necessarily involved, and this of course entails expense. It is much to be wished that we had in our possession some less elaborate mode of carbon determination. But we must remember that the difficulties disappear when care and time are taken; those who have tried the process have soon got over them, and there is no lack of analysts who now practise the method. The analysts representing the London water companies determined in 1883 the organic carbon and nitrogen in daily samples of all the London waters, and they still continue to employ it. The independent monthly reports to the Registrar General also state organic carbon and nitrogen. This combustion method has also been employed with satisfactory results for the analysis of small quantities of organic substances obtained in original research. On the whole, then, we may take it for granted that a comparison of any given effluent with the proposed standards can always be had, if desired.

The standard suggested for organic nitrogen is ·3, exactly ten times the amount of the standard proposed for potable waters in 1874. Thus the Act can hardly be said to be of too severe a character as regards organic pollution. It might perhaps have been desired by some that "albuminoid ammonia" and "acid permanganate" standard should have been proposed. Both these processes undoubtedly detect very bad waters, and might conceivably serve the purpose of an Act. In my opinion, however, the proposers have done well to say nothing about them. These methods determine a fraction only of the carbon or nitrogen, as the case may be; it is certain that, in many cases, the value of this fraction can be increased by simply prolonging the action of the re-agents, and it appears to vary with the season of the year. Results of this nature are clearly less definite than those of combustion. The combustion process goes to the root of the matter at once; it gives us an entire and perfectly distinct result, with all desirable precision.

(*h*) *Acidity.*—The proposed standard is two parts per 1000 of real muriatic acid; it was originally laid down in the interests of fish life. As regards the susceptibility of fishes to chemical re-agents, the best work with which I am acquainted is the report (1868) of Penney and Adams, published in the Fourth Report of the Rivers Pollution Commission. These experimenters show that one part of muriatic acid in 10,000 is fatal to fish, while of sulphuric or nitric, as little as one part in 50,000 will suffice. The standard is therefore at least 100 times too great.

(*i*) *Alkalinity.*—The proposed standard is one per 1000 of caustic soda, but according to Penney and Adams, one of caustic potash in 35,000 is a fatal proportion. The limit for lime has not been determined, but is known to be very low. Again, alkalinity is one of the most effective conditions for the development of bacterial life, and could not fail to intensify the foul state of the foreshores in many places. In my opinion it is not necessary or expedient to permit any alkalinity, however slight.

(*j*) *Chlorine.*—The effluent, after acidification with sulphuric acid, is not to contain more than one part per 100,000 of free chlorine. By re-calculating the results of Penney and Adams, I find that ·5 per 100,000 is a fatal proportion. Here again the standard is not sufficiently restricted.

Viewing the Act generally, I cannot but think that a clause is required disclaiming all *permission* of pollution up to the limits of the standards. No one, for example, ought to be allowed by law to foul a stream, already pure, by converting it into a ·2 per cent. solution of hydrochloric acid. Riparian proprietors ought, in such cases, to have their existing rights reserved to them. Let us also trust that all manufacturers may be treated alike.

As regards the outlook for manufacturers, there can be little doubt that in many cases it will be necessary to erect subsidence and treatment tanks and filters, and in all cases to collect and store the rainfall. This will be required for dilution and flushing. Land, therefore, will be in demand in the neighbourhood of country and suburban chemical works. Urban factories unable to purchase ground will have to execute works to perform the purification vertically instead of horizontically, but in many cases this plan will necessarily fail, discharge into the sewers must still be had recourse to, and the question will become one of sewage purification. On the whole, I should strongly advise manufacturers to support the early passage of this or a similar Act. As the popular knowledge of this subject is constantly improving, we may depend upon it that postponement will not bring easier terms.

Summing up, then, these considerations, it appears to me (1) that an Act for the better prevention of the pollution of rivers is urgently required; (2) that the principle of standards is a good one, and ought to be maintained; (3) that the proposed standards are of a very liberal character, and perfectly accessible to analysis; but (4) that the chlorine, acid, and alkali standards are not sufficiently stringent to preserve the life of fish.

Dr. Wallace: I have examined the new "Rivers Pollution Bill," with some care, and am glad to have this opportunity of expressing an opinion as to its merits and demerits. While, upon the whole, it is a distinct improvement on the Bill of 1876, it is imperfect, and I believe unworkable in many particulars. It appears to have been drawn up by men who, however eminent in scientific attainments, are only partially acquainted with the requirements and necessities of manufacturers. I have no doubt, however, that before the Bill is passed it will receive important modifications, such as would suggest themselves to any chemist who has had extensive experience in the difficulties of dealing with manufacturing pollutions.

At the outset I may refer to a very important part of the Bill of 1876—that is, section 7—which requires "sanitary authorities to afford facilities for factories draining into sewers," to quote from the rubric. It is proposed to repeal the Act of 1876. There is nothing in the new Act corresponding to the section to which I have referred, and I consider it a very important omission. I know of a case which dragged its weary course along for many months, the decision on which turned entirely upon this section 7 of the 1876 Act; and I have no doubt that there are many similar cases. It is necessary, therefore, that there should be some explanation regarding the omission of similar provisions in the Bill now under consideration.

The Act of 1876, except in so far as the section referred to is concerned, is about the most colourless and useless piece of legislation that can well be conceived; for all the prohibitory and preventive clauses are so explained away and hedged about with conditions that they are practically inoperative. We cannot say this of the proposed Bill of 1885, for the provisions are in some respects very stringent, and there is no escape from them. In one particular, however, the framers of the Bill are indulgent to a fault. They propose to admit into a river, stream or sewer any liquid possessing an acidity not exceeding two parts per thousand of real hydrochloric acid, or 140 grains per gallon. The admission into a river, still more into a sewer, of such a large quantity of acid is, in my opinion, most objectionable, and likely to lead to constant complaints. I would entirely prohibit the admission of acid of any kind to sewers or rivers; and I would have the less hesitation in doing so, because acid is easily neutralised by passing the refuse water over a bed of chalk or limestone, as is done in our own neighbourhood by Messrs. Stevenson & Carlile.

I propose now to refer to the standards of purity in the order in which they are printed in the Act. (*a.*) stipulates that no liquid containing in suspension more than one part of dry organic matter, or three parts of dry mineral matter per 100,000, shall be permitted to enter a stream. These quantities, being respectively ·7 and 2·1 grains per gallon, are, in my opinion, too small, and should be, at least, doubled. The river Clyde, above Glasgow, contains, during heavy floods, as much as 11 grains per gallon of suspended matter, mostly finely divided clay or mud; although in ordinary times the quantity is very small. Below Glasgow, ranging from Govan to Dumbarton, it contains, during ordinary weather, from 1 to 2½ grains per gallon of suspended matter, of which from ¼ to ⅓ is organic. No doubt the Clyde is a polluted river; but on many occasions the pollution in it and rivers generally, is caused, not by sewage or manufacturing refuse, but by the detritus of cultivated land; and is, therefore, entirely beyond the control alike of local authorities and manufacturers. On one occasion I had an opportunity of taking samples of the effluent from the sewage works at Birmingham, and of the river Tame into which the purified sewage flows. The effluent contained ·9 grain per gallon of suspended matter, while the river water had 14·2 grains, so that the sewage actually helped to purify the river. The same thing occurs at Bradford, when the sewage effluent, after filtration through breeze, is practically clear and colourless; while the water of the Beck is as black as ink, and very muddy besides. I admit that the rivers to which I have referred are more or less polluted, and would be vastly improved by the rigid enforcement of such an Act as that under discussion; but I fear that the high standard of purity aimed at is practically unattainable, or can only be attained by a pressure on our manufacturers, which will be very hard to bear, and which will inevitably lead to all sorts of evasions of a similar character to those practised under the Alkali Works Act. There is no one more anxious than I am to see our rivers restored to their pristine purity; but there is a possibility of pressing the manufacturers too hard, and driving the production into other countries, where such restrictions are unknown. If the proposed standards, as regards matter in suspension, were doubled, there would be no practical difficulty in complying with them. It is in this, as in many other things, the last straw which breaks the camel's back.

We now come to (*b.*), relating to organic matter in solution. This it is proposed to limit to two parts per 100,000 of organic carbon, and ·3 of organic nitrogen. This I find, on calculation, to be sufficient for all properly purified sewage; but in regard to manufacturing refuse water it is a standard compliance with which would entail very great hardships upon proprietors of works of various kinds. Here, for instance, is an example of waste water from a paper mill draining into a beautiful river in the north-east of Scotland; the caustic liquor, of a dark brown colour, but not strong enough to pay the cost of evaporation, contains upwards of 2000 grains of organic matter per gallon, the spent bleach 55 grains, and the general drainage of the works, mostly washings, 50 grains. In the case of another paper mill in our own vicinity, the general discharge of the whole work contains 334 grains of organic matter per gallon. Now, the standard in this Bill, two of organic carbon per 100,000, is equal to only 3·5 grains of organic matter per gallon; and these works could not possibly comply with it. No amount of neutralising, settling, or filtration would reduce the organic matter so as even to approach the standard; and it seems to me that if the Bill were to pass into law in its present condition, it would simply put a complete stop to the operations of every paper mill in the country. There might, indeed, be a door of escape for those who were so situated that they could turn into their works an enormous volume of clean water, so that their discharge would be diluted ten or twenty fold; but this would be a mere evasion of the Act, and one which comparatively few manufacturers could take advantage of. Again, with regard to dyers, I had recently an opportunity of examining the final effluent of six dye-works, and in all cases the amount of organic matter in solution considerably, and in some cases greatly, exceeded the proposed standard. Distillers making raw grain whisky give a discharge which contains an enormous amount of dissolved organic matter: in one particular case, recently investigated, it contained 810 grains of dissolved organic matter per gallon, and in another no less than 2466 grains. I admit that a considerable proportion of this consisted of albuminous compounds, dissolved in lactic acid, which, if neutralised by lime, as is done to a partial extent in some distilleries, would have been precipitated; but even after this the discharge would have required an admixture of at least a hundred times its bulk of pure water to bring it down to the standard. I shall only refer to two or three instances recently brought under my observation: A tar distilling work gave a discharge containing fully 400 grains per gallon of dissolved organic matter, a tannery 72 grains, an oil-refining work 40 grains, a gut work fully 600 grains, a skin-dressing work 186 grains, a soap work upwards of 2000 grains, a slaughter house 26 grains. In fact, there is scarcely a manufacturing operation in which animal or vegetable substances are treated, in which the waste water does not contain an amount of dissolved organic matter largely in excess of the proposed standard; and I trust the manufacturing interests of the country will not be hampered by such conditions as would, in a great many cases, simply mean annihilation.

The next standard (*c.*) refers to colour, and it is a very absurd one. It condemns "any liquid which shall exhibit by daylight a distinct colour, when a stratum of it, one inch deep, is placed in a white porcelain or earthenware vessel." This is far too indefinite: what is a distinct colour to one person would not be held to be so to another.

(*d.*) "Any liquid which contains, in solution, in 100,000 parts by weight, more than two parts by weight of any metal except calcium, magnesium, potassium and sodium." This I think is sufficiently liberal for all ordinary manufacturing operations, but in regard to water pumped from mines containing shales highly impregnated with pyrites, and the drainage of blaes heaps of a similar character, there would be some difficulty. These waters frequently contain, besides much free sulphuric acid, 100gr. per gallon, or more, of oxide of iron and alumina in the form of sulphate, and the treatment of the water is both troublesome and expensive. At the same time it is most desirable that these refuse waters should be treated, and the oxide of iron and alumina separated, before they are permitted to enter a stream. I know one considerable river the water of which has been completely destroyed by mine and blaes-heap waters. On mixing with a large body of river water containing a certain quantity of lime and magnesia as carbonates, the acid is neutralised and a curdy precipitate of oxide of iron with a little alumina is formed. This gets into the gills of fishes and is very destructive of life. The river I refer to was formerly celebrated for its trout, but I understand that fish has now entirely disappeared.

(*e.*) Refers to arsenic and (*f.*) to chlorine (set free by the addition of acid), and I don't see any reasonable objection to them.

(*g.*) "Any liquid which contains in 100,000 parts by weight, more than one part by weight of sulphur, in the condition either of sulphuretted hydrogen or of a soluble sulphuret." The difficulty I see in this provision is in regard to the drainage of heaps of alkali-waste, such as exist at St. Rollox and in the Newcastle district, Widnes, and several other towns in England. There are also in various places in the mining districts of England and Scotland enormous bings or heaps of blast-furnace slag, some of which, at least, contain enough sulphide of calcium to give a drainage water of a similar character to, although not so strong as, that from alkali-waste. The quantity it is proposed by the Bill to permit is ·7 of a gr. per gallon, but what do we find in practice? Why in the drainage of the Pinkstone Bog at St. Rollox there is over 900gr. per gallon of sulphur existing as sulphide and liberated as hydric sulphide in the addition of an acid, and in the general drainage of the heaps of alkali-waste there is more than 200gr. per gallon. Now, it is all very well for a scientific chemist to sit quietly in his laboratory and lay down the law to manufacturers—you shall not do this or that; but what are the manufacturers to do? Take the case of St. Rollox. I suppose it is no exaggeration to say that there are there something like 20 acres of ground covered by alkali-waste, and this will give an average daily drainage of, in round numbers, 50,000 gallons, a quantity the chemical treatment of which would be attended with considerable expense. More serious still is the question what to do with the drainage of the Pinkstone Bog, which derives its sulphur compounds from the same source which, although very strong in sulphur viewed as refuse water, is by far too weak to enable it to be treated chemically with any hope of recovering more than a mere fraction of the cost of working. These are an example of practical difficulties which should not be ignored in making out an Act of Parliament.

I have already spoken of the section relating to acidity, but *(i.)* relating to causticity demands a passing notice. It is proposed to allow in water flowing into a stream or river an alkalinity not greater "than that produced by adding one part by weight of dry caustic soda to 1000 parts by weight of distilled water." This is 70gr. per gallon, but whether it is intended by *dry caustic soda* to mean Na_2O or NaHO I am not quite clear. In any case the allowance, as applied to the general drainage of a work, such as a paper mill, is sufficiently liberal, in fact rather too much so. Now the alkalinity may be caused by either potash, soda, or lime; and although I am not prepared to say that the effect of the two *first* mentioned alkalies would be very injurious to fish life, except perhaps in the immediate vicinity of the outfall, I am certain that lime in this proportion, which would be, in fact, lime water of nearly full strength, would be most destructive. The mere fact of the injurious action of lime is well known to the riparian proprietors on all rivers stocked with salmon and trout, but I am not sure that the cause of the destructiveness has been explained. My own explanation, which I offer with extreme diffidence, is that the lime, becoming carbonated, forms a precipitate which gets into the *gills* of the fish and impedes their natural action. A very moderate quantity of lime introduced into a small river has been known to kill thousands of fish. This clause, therefore, would require some amendation.

The last clause *(k.)* applies to petroleum or hydrocarbon oil, the quantity of which is limited to ·05 per 100,000 parts, or ·035 of a grain per gallon. This relates only to oil floating on the surface or in suspension, but a much greater evil in connection with discharges from paraffin oil works and tar and ammonia works is the tar-acids existing in solution. It is true that these would be restricted by the clause relating to organic carbon in solution, but the amount allowed under that section would be infinitely more objectionable than the ·035 per gallon in suspension. I know of cases where great difficulty has arisen from the presence of a small quantity of tar-acids in water.

I am of opinion that there should be a clause obliging manufacturers to mix all their drainage waters together and allow them time to react upon one another and settle thoroughly, for which purpose at least two tanks, each capable of containing a day's produce, would require to be provided. It is no uncommon thing to see two discharges from a factory, one acid and the other alkaline, and these passing into a stream at different places. A great amount of purification frequently results from the mixture of various effluent waters, and there is often a considerable precipitation. It is most important that the precipitation should take place in the works themselves and not in the bed of the river.

The greatest difficulty in carrying out the provisions of this or any other Act for the prevention of River Pollution will occur in the case of factories situated in large towns where ground required for the erection of tanks is very expensive, and in many cases unattainable at any cost. It may be said that those who have no such accommodation or cannot procure it should not be allowed to continue their business. It is also a truism that no man should have a family who cannot provide for its wants, but as a matter of fact such cases are only too numerous. The industries upon which the prosperity of the nation depends should, if possible, be led, not driven; and at all events not improved off the face of the earth by restrictions with which, in very many cases, it is impossible to comply.

In conclusion, I enter my protest against the principle of making a hard and fast rule applicable to all cases, no matter what the circumstances may be; and, especially demanding a higher degree of purity in an effluent or discharge than exists in the river into which it flows.

Mr. E. C. C. STANFORD said: Our Society is not an exclusive one. We are always ready to accept light and intelligence, whether they come from the outside or inside. I am very glad to see present to-night several gentlemen who are eminently qualified to speak on this subject. Although they do not belong to us at present, perhaps they will soon. I have much pleasure in seeing Professor James Thomson, Mr. Deas, and Councillor Smith. All these gentlemen will no doubt give us something worth carrying away.

Mr. DEAS (Engineer to the Clyde Trust) said: I am very glad to learn, for the first time, that there is a prospect of some legislation on the purification of rivers. I think there is no river suffers more, in the kingdom of Scotland at least, than the unfortunate Clyde. When I consider we have to dredge about 500,000 cubic yards of deposit every year, the bulk of which is from the detritus of the streets, manufacturing waste products, and from sewage deposit, I hail with pleasure any prospect of getting an alleviation of the heavy burden that the unfortunate Clyde has to bear. There can be no doubt that the River Clyde is a great deal more impure than it once was. You don't see any salmon further up the river now than Dumbarton Castle, and no fish will live from Bowling up to Glasgow. I should hail the day personally when an Act such as you have been discussing to-night would bring back the fish to our rivers and enable us to see the salmon sporting at the Broomielaw. I fear, however, this is a prospect that we have little chance of seeing.

Councillor SMITH said: I came here to-night to learn, not to speak. I expected to hear something concerning this Rivers Pollution Bill, for certainly we do need a Bill of some kind or another. There are, however, vast difficulties that present themselves to my mind, both from a chemical point of view, as has been described to you to-night, and from an executive point of view, in putting any Bill into operation. We have a vast number of people who maintain that rivers are the natural arteries, for the carrying away of the *débris* of pollution. We have the opinion of one of the most eminent agricultural chemists, given at the last River Thames Commission who in his report maintained that the whole of the London sewage went to feed the fish in the North Sea. I refer to Sir J. B. Lawes, who wrote a letter, which the *Times* published *in extenso*. I candidly confess that I felt puzzled in reading this letter, and could not see how any sewage could help the fish in the North Sea, about 40 or 50 miles away. This, however, is Sir J. B. Lawes' view, and it is hard to say anything in opposition to such a scientific agricultural chemist, and you will easily see that there is great difficulty in carrying any Bill that will not present to any man vast variety of action. It is all very well to say that so many parts of acid and so many parts of liquid can be allowed to go into a river, but you will easily see that if half a dozen works have some pollution issuing from them the river will get into a highly polluted condition, and yet they are all acting in accordance with the Bill. I have felt this a great difficulty, and if you permit pollution of this kind to flow into a river it ultimately becomes entirely polluted. I confess to you that the more I look at this question of pollution I feel the greater difficulty in knowing what to do with manufacturers, for as Dr. Wallace has shown you there are a great many who have no ground to operate on their water, and what are we to do with these men? Either the community must supply sewers to take this matter down to a purification place, or must permit them to use the public sewers, and we all know what a nuisance these are to the inhabitants of the cities. The difficulties of this question are certainly great indeed, and all that can be done is to grope steadily at it, and we will ultimately come to some clearer idea of it than we have at present.

Mr. COLEMAN said: I am scarcely prepared to offer any observations, but I have a little experience in works which help me to say a few words. It appears quite clear to me that the standards of purity, which are proposed to be universally applied, would be utterly impracticable to carry out. There is nothing in my opinion to prevent standards being established for different parts of the country, by grouping the local authorities, appointed under the Bill, into districts.* I think the Bill requires very considerable modification, and probably if it is so modified might become satisfactory. The scientific basis on which these standards are proposed is, I think, not perfectly clear. For instance Professor Mills' opinion is that alkaline water is to be avoided, because it encourages bacterial life, but we have the opinion of Dr. Angus Smith that putrefaction is the best possible thing to occur, because it gets rid of the organic matter. Moreover it may be a question whether the presence of organic matter may not be sometimes an actual benefit to fish as food; so that to lay down any general rule or establish any general principle by which standards can be framed for the United Kingdom is, I think, utterly futile.

Dr. CLARK: It appears to me that the proposed Act is a considerable advance upon the Act of 1876. There can be little doubt that the present Act is a dead letter; and when we look to the cause we are led to the conclusion that this is due, in part, to the definitions. Thus, the Bill "prohibits solid matter from being discharged into streams," and when you come to the definitions you find that "solid matter" does not include matter in suspension, and that discolouration is not to be regarded as pollution. Again, we find also that, under the present Act, the sanitary authorities of the Local Government Board are the only parties who can institute proceedings against offenders; and they are expected to take into consideration whether there are good practical means of removing the pollution, and whether it would affect the trade or manufacture in question. Under these conditions, where there is so large a discretionary power, it is not surprising to find that the sanitary authorities are not inclined to take any proceedings against offenders, however great. In the present Bill, I observe that sanitary authorities will have less discretion allowed them, and that I consider a good feature. Another good feature is the introduction of standards. Without some standards of purity we are not able to grapple with pollution. We must, in my opinion, have standards laid down to enable us to decide what is pollution and what is not. The question, then, comes to be what particular standards are to be adopted? With most of the standards proposed I can find very little fault. I consider that rather too much acid and alkali is allowed; and I have no fault to find with the allowance of matter in suspension. The only two points to which I would take exception in the standards, are (1) "the limit of two parts by weight of organic carbon in solution." In some cases this is a considerable allowance; but in others, when the organic matter is of a harmless nature, it would press very hard upon manufacturers. Perhaps the particular standard of purity to which I take most exception is standard (c), which follows: "Any liquid which shall exhibit by daylight a distinct colour when a stratum of it one inch deep is placed in a white porcelain or earthenware vessel," etc. Now if this was very strictly interpreted, there are very few liquids which would pass this standard; and we know that many of our waters, especially those of a mossy or peaty character, have a distinct colour when seen in a stratum of one inch deep. In order, therefore, to make this a practical standard, it is necessary to compare the colour of the discharge with the colour of the particular water as it reaches the manufacturer. It is only in that way that you can ascertain whether a water is polluted; and I think it only fair to allow the manufacturer some little increase upon the amount of colour—to what extent I am not able to say—otherwise it would be practically impossible for him,—especially if he is the owner of a dye works, or some work where coloured materials are used—to discharge his water into the stream again. In other respects I think the Act is, as I have already stated, a step in the right direction.

Mr. TATLOCK said: I object to the Bill on two general grounds: first, because it treats all manufacturers alike. It is quite plain to every one who has a knowledge of a variety of manufactures, that while it would be quite easy, in some cases, to comply with the requirements of the Bill, it would be a matter of extreme difficulty, in fact it would be practically impossible, in many others to do so; and sufficient examples have been given. Second: I object to the Bill because it treats all rivers alike, no matter what their character or situation may be. It is evident that, while a commercial river like the Clyde, receiving so many discharges from chemical works, is not expected to attain to any great degree of purity, as the result of legislation, it is most desirable that rivers which are still unpolluted should remain so. I hold, therefore, that much more stringent legislation is required for those streams which have not as yet been defiled, than for those which have been *for many years in a polluted* condition. I also am of opinion that some of the standards of purity are too loose, and others too stringent.

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* Chemical referees being appointed for each district.

Professor Mills said: As regards the hardship to individual manufacturers. No doubt there are many cases that would necessarily arise, especially *in the case of manufacturers* who have standard processes which have been going on for a great many years, and resulting in a great deal of pollution; they cannot be expected to reform these in a short time. I certainly think, in a vast majority of cases, that the pollution might be very fairly dealt with by an Act of this description; and in the majority of cases there would be no hardship. If I were about to set up a dye works, such as exist in the Vale of Leven, I should prefer to do so in the heart of Glasgow. I am quite certain that any pollution I should produce would be more leniently dealt with in any future bill, than it would be if I had gone to the outskirts of Glasgow. I think that we neglect sea water in a great many towns not far from the sea, that greatly pollute rivers, where it would be easy to pump up water to wash down the impurities. Then, again, after all that has been said and done, there will *be cases of extreme hardship, and cases with which* the scientific chemist cannot immediately deal. I think if there was a court of appeal to certify the cases that are exceptional, and a committee of experts appointed by the Home Secretary to see what could be done, that it would meet this difficulty fairly well. It has been thought desirable by the Council of the Society that we should come to some resolution on the matter; and as there is, I think, a general consensus of opinion that such an Act is necessary, although not perfect as regards detail, I therefore propose for your acceptance the following resolution: "That, although this meeting considers the subject proper for legislation, it does not approve of 'The Proposed Rivers Pollution Bill,' in many of its clauses, and instructs the committee of the Section to make such communications, as it may see fit, to the General Council of the Society."

Dr. Wallace, *in seconding the resolution, said*: This resolution does not bind us in any way. It is simply an expression of what we have virtually decided upon—that the Bill, although good in the main, is imperfect in many of its details. It only commits us so far as that; and we, as a meeting, throw the matter upon the committee to report to the General Council in London upon the subject. The General Council have asked our opinion on this subject, and the least we can do is to give them the benefit of our counsel and advice.

Mr. Stanford, in putting the resolution to the meeting, said: I would simply add that I am quite sure the committee will do their best to put the prominent points that we object to in this Bill before the General Council. I would mention one particular with regard to the standards, that although some of them have been proved by Dr. Wallace to be high (*I allude to the carbon and nitrogen*), those for the acids and alkalis are far too low. No one would dream of running a waste liquor into the river having anything like the acidity or alkalinity allowed by the Bill. It is remarkable that while so much is said about quality, nothing is said as to quantity, thus, as Dr. Wallace has already said, evasions can very easily be carried out. He fancied, probably, that they would not be, but my impression is that they would. There is no doubt that nothing can be easier than to pump a large amount of water from the river to dilute the effluent down to these standards and thoroughly come under the Act, and yet at the same time pass the *same amount of pollution into the river.* That appears to have been overlooked by the authorities. But why should we have any standards at all? It appears to me that a simpler way would be to require every one to put back into the river the water he drew from it in no worse state than he got it. With regard to the case of the Bradford Beck, to which allusion has already been made, it does seem absurd that the Corporation should have been interdicted for several years from passing their sewage into that river when it was thoroughly well proved that it would have made the river half as good again. My own opinion goes in favour of the suggestion made by one of the speakers in London, that we should go back to the Rivers Conservancy Boards. I think the rivers do want looking after, and would, in my opinion, be better looked after by a Board which does nothing else.

The motion on being put to the meeting was unanimously adopted.

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Obituary.

SIDNEY GILCHRIST THOMAS.*

BORN APRIL 1850; DIED FEBRUARY 1, 1885.

We regret to announce the death, at Paris, on Sunday morning, February 1, of Mr. Sidney Gilchrist Thomas, to whose genius and untiring labours the basic Bessemer process chiefly owes its existence. In him the metallurgical world has lost a bright and useful ornament.

Sidney G. Thomas was born in April, 1850, and was educated chiefly at Dulwich College, with a view of entering the medical profession. His father's death, however, rendered this impossible, and at the age of seventeen he entered the civil service. Though his position was connected with the administration of the law, a legal training was not a necessity; but it is an illustration of the thoroughness which characterised him that he devoted a considerable time to the regular study of law, in order, as he thought, to be better qualified for his daily work. *His predilections,* however, lay in a scientific direction, and to chemisty and metallurgy he was specially devoted. Engaged during the day, his only opportunites of study were in the evenings. A small laboratory at home was the scene of much of his study, in which he obtained further guidance by attendance at the laboratories of Mr. Arthur Vacher, of Great Marlborough Street, and of Mr. George Chaloner, of the Birkbeck Institution. However, Sidney Thomas was really an outcome of the admirable system of popular scientific instruction organised by the Science and Art Department.

It was in 1870, while attending a course of lectures on metallurgy at the Birkbeck Institution, that the idea of dephosphorisation first took strong hold upon his mind. To use an ex-

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* For the matter of this obituary, the Editor is mainly indebted to the excellent article in *Iron*.